COTTON MANUFACTURING

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BY

C. P. BROOKS,

EXAMINER TO THE CITY AND GUILDS OF LONDON INSTITUTE; SEN. HONOURS MEDALLIST, COTTON MANUFACTURING, 1887; LATE LECTURER ON COTTON SPINNING, WEAVING, AND DESIGNING, AT THE BLACKBURN TECHNICAL INSTITUTIONS.

WITH OVER EIGHTY ILLUSTRATIONS.

Third Edition.

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PREFACE.

THE lack of books relating to the weaving of cotton goods is the motive which has led to the production of this work. Although several admirable books are extant on special branches of textile industry, few, if any, works claim to treat practically of the whole range of processes popularly known as Cotton *Manufacturing* as at present conducted, and which, at the same time, are within reach of the artisan's pocket.

This class of work is all the more requisite in consequence of the admirable system of trade education introduced by the City and Guilds of London Institute, whose syllabuses for the subjects of Cotton Manufacturing and Weaving and Pattern Designing are included in this work. It is hoped that the student in either of these subjects may find a handy book of reference in this volume, which goes into explanatory details to as great an extent as space allows.

However, as the author has found, and doubtless many others actively engaged in the industry have discovered, it is becoming a requisite in the mill that those employed there be possessed of something more than "rule of thumb" systems of working—that careful and intelligent research and investigation is necessary to success in every department. The writer trusts that this volume, based on practical experience and on the application of theoretical principles in the industry, may prove of assistance to such.

In addition to chapters on Weaving, in which reference is made to most of the plain and figured fabrics woven in cotton, space is devoted to the preparatory processes, especially to the

important one of Sizing; a chapter on Mill Calculations is added, as well as a Glossary of Technical Terms—necessitated by the nomenclature of different districts.

Acknowledgment is made of the assistance rendered by many correspondents, whose suggestions have been, and will be, welcomed. The thanks of the author, and it may be added those of the reader, are due to the many firms who have lent blocks to illustrate and simplify the letterpress. Amongst these may be mentioned Messrs. David Sowden & Sons, Shipley; Butterworth & Dickinson, Burnley; J. H. Stott, Rochdale; Devoge & Co., Manchester; Willan & Mills; Ward Bros.; and W. Dickinson & Sons, Blackburn; whilst especial mention should be made of Messrs. Howard & Bullough, of Accrington, whose sizing machinery has been selected for description; and of Messrs. Hy. Livesey, Limited, Blackburn, whose well-known weaving and preparatory machinery is engraved.

C. P. B.

THE MOUNT, BLACKBURN,
January, 1888.

PREFACE TO THE SECOND EDITION.

IN this edition some necessary additions and alterations have been made, especially in the statistical portion of the work; and as the City and Guilds of London Institute have altered the Syllabus of the textile subjects during the few months that have elapsed since the publication of the First Edition, the old Syllabus has been replaced by the new one. Apart from these alterations the book retains its original form, and the author hopes that this issue will obtain from those interested in cotton manufacturing the same kindly appreciation as the former edition.

C. P. B.

April, 1889.

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COTTON MANUFACTURING.

CHAPTER I.

INTRODUCTORY, HISTORY, STATISTICS, COTTON AND COTTON SPINNING, MANUFACTURING.

IN the general acceptance of the term, manufacturing is understood to refer to the whole range of processes which convert a raw material into the finished article, but whatever that word may usually signify, in the Cotton Trade it is technical for that department only, which comprises the conversion of cotton yarn into woven fabric, and as such is understood in the ensuing pages.

This department is frequently worked apart from spinning, and the gradual and marked severance of the cotton industry into the two great departments of spinning and manufacturing is a striking feature of this great trade, although the reason of cotton spinning finding so fertile a soil in South Lancashire is no more apparent than the cause of North Lancashire being so favourable to the prosperity of cotton weaving. Probably accidental causes in the early days of the trade had much to do with its future division—the fixing upon a South Lancashire town for the establishment of the first spinning machinist's works, the fact that the factory system was firmly estab-

lished in the spinning department before the working of looms in one building was possible, or at any rate advisable, and the existence of large warehouses in North Lancashire for distributing to the hand-loom weavers their materials for use, were probably some of these causes.

The fact of the trade being carried on in two divisions, each in different districts, has its disadvantages, the greatest being that of additional carriage—an extra cost of no inconsiderable amount. To remove this and other disadvantages, many attempts have been made to introduce the lacking department both in the North and South of Lancashire, but such attempts have generally failed to a greater or less extent, mainly in consequence of the incompetence of the hands, or rather the insufficient number of competent ones. Where the majority may excel in weaving, the number of good spinners is generally very small, and *vice versâ*. Another objection is the disadvantage at which the one party is placed should the production of one part of the industry exceed that of the other, the margin which might serve to provide remunerative occupation for both being at present often unequally distributed, the over-producer taking the lower position. On the contrary, there is no doubt that the skill of the operative is more greatly developed where one district takes up a specific branch of the sub-divided labour, and conducts it in a more fully equipped style, than would be the case were it to be attempted on a small scale.

The known pre-eminence of Manchester as the market town is attributed in part to the necessity for some common centre where a meeting of the representatives of each of these industries could take place to transact the business of the trade. The Exchange of Cottonopolis is that centre. Here, every day of the week, but more especially on the Tuesday and Friday market days from all parts where the cotton trade is conducted, the spinner goes to meet the manufacturer, the manufacturer to meet the merchant, who in turn represents all countries to which our manufactures are

exported; and thus the Exchange has become, as it were, the heart of the trade, for on it depends the prosperity of the whole industry, and a stoppage or diminution of the business there paralyses the trade.

The movement of the cotton trade, like that of civilisation, has ever been westward. India is recognised as having been from time immemorial its home, and although there cotton has probably been in use for ages as clothing, there is no evidence to show that the substance was even known in Europe till the tenth, or that its manufacture was commenced in England till the end of the sixteenth, century. At *that* time the weavers used yarn made from "cotton wool," as it was called, but which yarn was furnished by the Levant and only used for weft, linen forming the warp. However, the invention of simple hand-spinning apparatus rendered it possible for the ever-increasing demand for cotton yarn to be adequately supplied for a time by English spinsters, and it is chronicled that, in 1701, 1,900,000lb. of raw cotton were imported, although it is improbable that the whole of it was required for conversion into cloth. At the beginning of the eighteenth century such inventions as that of Kay's fly shuttle so increased the output of the hand loom as to cause for some years a dearth of yarn. This had a good effect in inducing the great era of invention in cotton-spinning machinery, from 1760 to 1780; during which time Hargreaves, Arkwright, Crompton, and many lesser lights brought before the world the results of their labour. These inventions, the importance of which it is not necessary to refer to—their details and the story of their invention having been so frequently dilated upon—these *created* the cotton manufacture.

The cause which influenced the development of spinning machinery was antithetical to that which now caused an extension of the weaving, which was an excess of the supply of yarn, and for which the only consumers were the loomshops attached to scattered houses on the country side, containing one or two ponderous handlooms.

It is rather more than a century since the Rev. E. Cartwright, a Kentish minister, first gave his attention to the invention of a power loom, and although his first patent in 1785 was not satisfactory, yet it is to this clergyman's efforts that the world is indebted for the first power loom. In 1787, he patented such a machine, fitted with spring motion, batten or slay, temples, etc., with the addition of a protector and weft stop motion in an imperfect form. Nine years afterwards Robert Millar, of Glasgow, applied to it the means of picking by plates and shedding by tappets or wipers.

Here all the principles of the modern loom were present, although in very different form, and it is only in details that the loom of a century later presents a different aspect. In 1834 the weft stop motion was patented by Messrs. Ramsbottom and Holt, which was perfected seven years later and patented in its present form by Messrs. J. Bullough and Kenworthy, of Blackburn. To these gentlemen is due the invention of an improved dressing machine called a "tape," the forerunner of slashing; also the take-up motion for cloth. They, too, patented the loose reed loom and the roller temple; but from records of the time and tales told by the older section of the community in Blackburn to-day, apparently, it is to John Osbaldeston "that the honour is due of breaking the concussion of the loom and inventing an improved temple. He also originated many of those inventive appliances so essential to adapt the power loom for weaving fancy goods, but was not successful in securing any pecuniary advantage to himself, thus illustrating the fact that not every benefactor of his species meets with the reward due to his merits."* The creative spirit which carried cotton-spinning machinery to so high a degree of perfection, was directed also to the improvement of the preparatory machinery of the weaving department.

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*Alderman Baynes' Lectures, 1857, at Blackburn.

In the hand-loom days each weaver stiffened or dressed his own warp whilst it was in the loom, applying the size with a flat brush. A length of about two yards was sized in this manner, and dried by means of hot irons being passed over the surface of the warp, paper being first laid over the damp twist, or by means of a fan; grease afterwards being applied. In the face of our modern systems this old-fashioned method hardly appears credible. The paste used was a mixture of flour and water, boiled over the fire, and stored in a stone vessel not unlike a swine trough. Probably from this reason the term "sow box," indicating in our modern "slashers" the size vessel, arose; and etymologists may find some connection between it and the word "sowlin'"—a common expression in Lancashire for a mixture of the nature referred to—of its intended use or application. The necessity for this was removed by the invention of the dressing machine by William Ratcliffe and Thomas Johnston, his assistant, of Stockport, in the year 1803, by which warps were sized before putting them in the loom. This dressing machine consisted of little more than a frame with rollers to carry the warp from two back beams, one at each end, to the centre where the weaver's beam was fixed, whilst between were arranged brushes traversing to and fro by means of rods actuated from a crank in the so-called crank dressing machine, to apply the "sow" or size. In addition there was a wooden fan to dry the warp, which passed through the healds and reed also.

Dressing was in vogue until 1830 without any competitive system, but soon after this the tape frame, producing five times more work than the dressing machine, was invented, and continued in use until in an improved form—delivering the yarn direct to the weaver's beam, and with still further capacity for large turnout of work—it under the name of the "slasher" takes the lead among all sizing systems now current, which important position is attributable to a great extent to the speed and to the good quality of the turn off.

To James Bullough, a native of Westhoughton (though from early life a resident of Blackburn), may

be credited this last invention, which brought in its train the beam-warping frame, and found increased employment for the winding frame invented early in the century by the senior Robert Railton.

The factory system was deeply rooted in the spinning department before we hear of any attempt at gathering a large number of looms under one roof. Arkwright had a spinning mill as early as 1771, but the first successful weaving shed was built in Glasgow in 1801 by Mr. Monteith, and contained 200 looms; previously, in 1790, Messrs. Grimshaw partially erected one at Knot Mills, near Manchester, which was burnt to the ground by a mob of hand-loom weavers. In 1813, we learn of 2400 power looms being in use in the United Kingdom. Since then the number of factories has rapidly increased, and excepting for the effects of occasional deterrent influences, such as war and famine, the cotton manufacture has steadily prospered and extended. 250,000 hand-loom weavers, and 30,000 power-loom weavers were engaged in all weaving trades of all materials in 1833. Now, in 1887, 250,000 power-loom weavers are engaged in the cotton industry alone; while in most districts a hand loom is a curiosity as a relic of the past. The contrast is great, more especially so when it is remembered that during the same period the trade has been established in many foreign countries where nothing but handicraft skill was available at the early part of the period, but where now the number of mules and looms has grown, and is growing, so rapidly as to create out of former consumers important competitors in the export trade.

The recent history of cotton manufacturing has been marked by little which has caused extensive alterations in its methods.

The extensive and well-organised association of the operatives for the protection of their position in relation to the masters, has become a power, as shown by the great strike of 1878, when the operatives were able to resist the masters for a period of nine weeks, and by the increasing influence of the employés in all trade questions. The more important Parliamentary proceedings

relating to the cotton trade during the time of its being conducted on the factory system are, of course, the Factory Acts. The first important legislative enactment was the Factory Act of 1833. By this no young person under 18 was allowed to work before 5.30 a.m. or later than 8.30 p.m., nor more than 12 hours per day, although 3 hours extra might be worked per week to make up for lost time. Children had to be 9 years old, and had not to work more than 48 hours per week till 11 years of age, having 2 hours' schooling per day to be provided by the employer. In 1844, females over 18 were granted the same privileges as young persons, and children were allowed to work $6\frac{1}{2}$ hours per day if only 8 years old. Work had to cease at 4.30 on Saturday. In 1846, the hours of labour were reduced to 11 per day, and 63 per week for children, young persons, and females. Only minor alterations were made till 1874, when the Ten Hours' Bill was passed, limiting work to 10 hours per day, and $6\frac{1}{2}$ on Saturday. In 1878, all the previous Acts were repealed and a new one made which is still in force, and requires that for young persons and females the hours be limited to 10 per day, and $56\frac{1}{2}$ per week; that no child be employed at all under 10 years of age, or under the Second Educational Standard; and only half-time below 13 unless the Fourth Standard of Elementary Education shall have been passed, failing which the limit is 14 years of age. Males and females under 18 are deemed young persons, and all young persons and females possess certain advantages over the male workers, which rights are protected by Government inspectors. The Bill was a lengthy one, and contains many restrictions as to holidays, painting and cleaning, reports of accidents, fencing machinery, and school attendance, for the benefit of the employé.

The Limited Liability Act of 1862 gave great facilities for conducting business by companies of more than seven members, whose liability in case of a collapse does not exceed the amount promised on formation—a scheme inaugurated for the benefit of the working classes, but which has been misapplied in many instances.

The Employers' Liability Act of 1880 gives facilities for recompense to the workmen for accident or injury sustained by the negligence of the employer or his deputies, such liability being incurred under certain conditions only, and being restricted to the amount of three years' salary.

The Merchandise Marks Act of 1887 has caused a reaction in the tendency towards short lengths and false description, by making it a penal offence to falsely mark goods either in respect to dimension, quality, counts, or place of manufacture.

In addition to these, the variation of tariff charges, notably the reduction of Indian tariffs, the returns and reports to Parliament of statistical information, the Inquiry Commissions, and some few small enactments, all have their influence in a greater or lesser degree on the industry.

The cotton goods of a standard make at the commencement of this century comprised printer, muslins, corduroys, fustians, sheetings, shirtings, twills, ginghams. In 1830, records give madapollams, tanjibs, domestics, jacconets, gauze leno, figured muslin, splits, and velveteens. Later, in 1846, there are chronicled lawns, books, nainsooks, figured counterpanes; and, in 1864, brilliante, chambrey, blue mottle, satin checks, in addition to previously mentioned goods, from which list the absence of dhooties, Turkey reds, Turkish towels, and cloths of later origin will be noted.

A comparison of the position of the cotton trade to-day with what it was some thirty years ago shows a decided change in one respect—*i.e.*, in the firms conducting the business. Many of the old private firms have disappeared and their places been taken by companies, while, for many years back, the tendency has appeared to be in favour of carrying on the trade by the co-operation of small capitalists. Some of these companies are not limited, being formed by a few speculative operatives who invest the savings of a frugal lifetime in the mill concern, to which they also devote their labour, being satisfied at the year's end if they have drawn an ordinary wage, week

by week, while the capital has been added to, and increased. Manufacturing, in consequence of the comparatively smaller amount of capital required, is generally selected for the above system.

To these establishments many of the wealthy manufacturers of North Lancashire can trace the beginning of their prosperity. By far the greater number of these companies, however, especially in spinning, are on the limited liability principle, and their increasing number shows how valued, as an investment, such companies are; so much so that it appears not unlikely, what with the narrowing margins and increased competition, that the trade will, at no very distant period, cease to be a means of making the wealthy cotton lord, and, as the trade falls into the hands of gigantic companies, become merely a bank, with a small rate of interest, in which the wealth of the smaller Lancashire capitalists will be locked up.

This carries our thoughts to another branch of the subject—the importance of the trade with regard to the capital invested in it, a sum which cannot fall short of seventy-five million pounds even in Great Britain alone, without taking the allied industries of machine-making, dyeing, calico printing, lace and hosiery manufacturing into account. By dipping into calculation, taking the spindles at the figure of 17s. 6d. each, and the looms at £16, the amount invested in plant will touch £45,000,000, and adding to this a floating capital of £30,000,000, fully which will be necessary to the trade in importing the raw material, converting it into fabric and distributing the same to the world, a total sum is obtained which indicates what is at stake in this mighty industry.

Statistics.

A perusal of the subjoined list will indicate in figures the extent of the trade, and from it will be observed the comparative importance of our trade with each country. Taking the value of the exports of piece goods only as the

standard of comparison, the list of countries will be found as follows:—

Exports of Cotton Manufactures—Piece goods of all kinds.

COUNTRY.	QUANTITIES. Twelve Months ended December.		VALUE. Twelve Months ended December.	
	1886.	1887.	1886.	1887.
			£	£
Germany ....Yds.	45,358,400	40,765,000	676,321	626,104
Holland	34,132,200	43,203,200	519,491	590,154
Belgium	61,499,600	65,712,700	867,666	921,207
France	35,474,900	34,585,300	681,047	598,531
Portugal, Azores, and Madeira....	54,312,300	66,761,400	563,006	683,429
Italy	85,053,900	119,961,500	965,010	1,364,075
Austrian Territories	6,391,200	5,946,800	76,291	72,245
Greece	36,020,900	35,860,000	429,066	454,862
Turkey	299,706,200	299,824,400	3,358,980	3,271,768
Egypt	139,384,500	156,150,900	1,280,335	1,391,736
West Coast of Africa (Foreign)....	37,493,200	46,394,300	427,945	547,784
United States.....................	45,251,600	44,028,500	1,148,955	1,054,221
Foreign West Indies	90,237,900	95,223,700	922,322	973,227
Mexico...........................	32,312,200	35,412,200	359,932	380,378
Central America	37,503,800	53,490,800	379,280	522,006
United States of Colombia........	42,905,800	61,637,100	425,716	572,082
Venezuela	23,710,200	44,697,300	239,287	446,528
Brazil	241,034,500	215,370,400	2,679,273	2,517,899
Uruguay	35,732,600	49,767,800	414,497	615,685
Argentine Republic	104,812,100	105,585,100	1,224,586	1,394,604
Chili	59,701,800	73,694,800	562,722	768,366
Peru	33,593,000	23,894,800	354,389	251,189
China and Hong-Kong	455,823,000	552,742,700	4,570,207	5,624,953
Japan	34,628,500	65,403,800	383,500	699,462
Dutch Possessions in India	86,511,500	105,572,700	928,813	1,082,348
Philippine Islands................	43,214,700	39,247,900	481,513	387,062
Gibraltar	12,082,300	17,424,300	138,767	190,988
Malta	24,021,500	16,987,100	250,668	175,010
West Coast of Africa (British)	28,502,600	38,584,300	318,964	414,283
British North America	32,584,700	33,692,500	634,158	620,378
British W.I. Islands and Guiana..	42,723,200	51,593,100	489,367	582,803
British Possessions in S Africa....	21,465,800	32,443,300	341,689	523,845
British East Indies—				
Bombay ....Yds.	797,776,900	647,673,400	6,871,733	5,737,475
Madras	142,687,200	126,804,300	1,408,193	1,296,161
Bengal	1,178,374,300	1,037,464,800	10,207,523	9,422,554
Straits Settlements	103,929,600	144,570,800	949,983	1,325,562
Ceylon	14,868,200	16,914,200	160,201	184,024
Australasia	96,756,600	91,399,900	1,700,432	1,551,069
Other Countries..................	152,629,100	165,262,100	1,779,844	1,907,257
Total..........	4,850,210,500	4,904,109,200	50,171,672	51,743,314
Total—Wholly of Cotton—				
Unbleached or Bleached........	3,497,866,100	3,473,477,400	32,237,682	32,812,846
Printed Dyed, or Coloured	1,351,976,700	1,430,537,600	17,922,454	18,925,985
Total of Mixed Materials, Cotton predominating	367,700	94,200	11,536	4,483
Total..........	4,850,210,500	4,904,109,200	50,171,672	51,743,314

In 1886, according to the estimate of Messrs. Ellison, of Liverpool, the number of spinning spindles in various parts of the world was as follows:—

Great Britain	42,700,000
Continent	22,900,000
United States	13,350,000
East Indies	2,100,000
	81,050,000

In a recent estimate published by Messrs. Worral & Co., of Oldham, the spindles and looms engaged on cotton in Lancashire and its borders are given as 40,946,709 spindles, and 582,504 looms. This does not include other parts of the kingdom, nor a number of looms just now starting; therefore we may without erring take the number of cotton looms in the kingdom at about 615,000. In India there are 18,536 power looms.

The number of persons employed is :

Males	196,378
Females	307,691
	504,069

of which 465,654 are in England and Wales, 37,167 in Scotland, and 1248 in Ireland.

Cotton Districts.

Taking into consideration the various districts of Lancashire, Blackburn is the most northern of those which take an important part in the industry, and this town also takes the lead in Lancashire, if not in the whole world, with regard to its importance as an exclusively cotton manufacturing town. The class of goods made are of a plain character, principally shirting, mulls, and jacconetts, while a large number of looms are engaged on dhooties, grey and coloured, which goods were introduced from Glasgow. A large quantity of dobby dhooties are manufactured in this district—this class of cloth, of comparatively recent origin, having been

first made in Blackburn. The local spinning industries are now very important, most of the spindles being run by those who are also manufacturers.

Darwen weaving trade is of a similar character, and there is a fair trade in yarn by several sale-spinning mills.

The neighbouring towns of Preston and Chorley have a connection with goods of a distinctly finer and more "fancy" character, such as leno, velveteen, damasks, embroidery, and brocades, while the plain trade, including the well-known home trade shirting, is important. Here also the spinning trade is comparatively small, the yarns spun being 40/80's T and 40/90's W.

Burnley is remarkable for the recent increase of cotton manufacturing within its borough, and has a most extensive trade in Burnley printers and shirtings, with a few heavy twills—ranking second to Blackburn in quantity produced.

Accrington, Harwood and district have a plain trade, but in yarns the goods are of a much finer character than other plain districts. A large business is done in the better classes of printers for the supply of the local print and dyeworks.

The spinning of medium fine yarns, 40/200's, from Egyptain cotton, seems to be centred in Bolton, as is also the manufacture of heavy fancy goods, especially Alhambra, Marseilles, and other counterpanes and towels, with some finer fancies—leno, damasks, and velvets; although many mills are to be found engaged in Blackburn goods.

Haslingden, Bacup, Rawtenstall, and many smaller districts in East Lancashire are engaged on manufactures of coarse and heavily-sized goods, shirtings, T-cloths, Wigans, and domestics.

Manchester, while being pre-eminently *the* English market of the manufactured cotton goods, is also known as the locality where the finest yarns known to commerce are spun—*i.e.*, yarns from Egypt, and Sea Island cottons, 80/200's in twists, and 80/350's in weft. The finer numbers, however, are not used for the ordinary purposes of manufacturing, their consumption being divided

between the lace curtain manufactories of Nottingham and the great sewing thread factories. The weaving trade of Manchester consists of checks, ginghams, Harvard and Oxford shirtings.

Oldham is, it is needless to state, *the* spinning town. Here the coarsest yarns, 4/24's, made out of the waste from finer mills, have their spinning centre, and here the spinning of medium yarns from American cotton has made the name of the town familiar wherever English cotton yarn is known.

Rochdale depends mainly on the coarse trade, 12/24 warps (water T) made from Indian cotton, together with some mule spinning up to 30/40's. The weaving of the heaviest cotton goods from waste, twills, sheets, T-cloths, velveteens, fustian and cords, is here carried on.

Mossley, 30/50's, warp yarn; Shaw Lees, Royton, Dukinfield, Ashton, Heywood and Hyde, may be placed in the same category as Oldham, minus the waste trade.

Stalybridge spins 30/150's.

Stockport has good trade in spinning, as high as 150's gassed and doubled yarns with varied weaving, including the well-known Turkish towels.

Nor must the other parts of the United Kingdom be forgotten. Cotton weaving extends no further into Yorkshire than Todmorden, and about 2,000,000 spinning and doubling spindles are in use about Halifax, Brighouse, Sowerby Bridge and district, these being employed on yarns for dress fabrics made of a mixture of cotton and worsted, as well as for curtains and hosiery in the Nottingham and Leicester districts. In Scotland, the cotton trade is confined to the counties of Lanark, Renfrew and Ayr. The spinning trade is here going down rapidly, there only being about one third the number of spinning spindles running this year (1888), as compared with 1857. The doubling spindles are on the increase, especially for the Paisley thread trade. The weaving department is also increasing, there being in the three counties 28,853 looms as compared with 20,963 in 1856. The superior classes of cloth are made for the home trade—fine reeds, fine muslin, plain and figured, and the manufacture of

Turkey reds is also extensive. In Ireland there are three cotton-spinning firms, three cotton-weaving firms, and one both spinning and weaving, with a total of 70,900 spindles, and 2501 power looms.

Summarising the different classes of work into which the industry is divided, we may allot to the coarse plain trade the Rossendale Valley and Rochdale, locating the medium plain trade in Blackburn, Burnley and Darwen, with the finest plain goods in Accrington and Preston, the light fancy trade in Preston, Chorley, and Ashton, and the heavy fancy in Bolton and Bury.

Cotton.

Even in a manual treating of the weaving processes it is not foreign to refer succinctly to the cotton and the treatment it has undergone to fit it for use in a weaving shed. The manufacturer who has had experience in a spinning mill often finds the knowledge acquired there to stand him in good stead in the selection and use of the yarn. Our chief supplies of cotton are drawn from the United States of North America; next in importance, although far removed in quantity from the first-named, is East India, then Egypt, and lastly Brazil. Cotton is a fibrous vegetable substance, being the fruit of the cotton plant, a shrub of the *Malvaceæ*, genus *Gossypium*. There are several varieties of this plant, but the development of the raw material is the same in each. The plant attains its full height about June (this being about two months subsequent to sowing), and the bolls or seed pods are found to be ripening about the middle of July. These bolls, about 1in. diameter, are divided by membranous walls into three parts, containing three or four seeds each, covered with the thin transparent cylindrical fibres attached by one end to the seed.

As the fruit approaches maturity, these fibres lose their cylindrical form, becoming ribbon-shaped through the collapse of their walls, and at the same time each fibre twists on its axis, thus causing a sufficient pressure on the interior of the boll to burst it at the junction of the compartments in the outer casing.

After being left on the trees for some days, during which time the ripening influences are at work, increasing the convolutions and maturing the fibre—or exposed perhaps in the case of unfavourable weather to the damaging influence of rain, which stains the cotton, or intense heat which renders it brittle, or wind which fills the boll with sand or leaf—the cotton is picked. It is then passed through a gin, a machine which has for its object the separation of the fibre from the seed. This latter, which in medium-stapled cotton exists in the proportion

FIG. 2. FIG. 5.

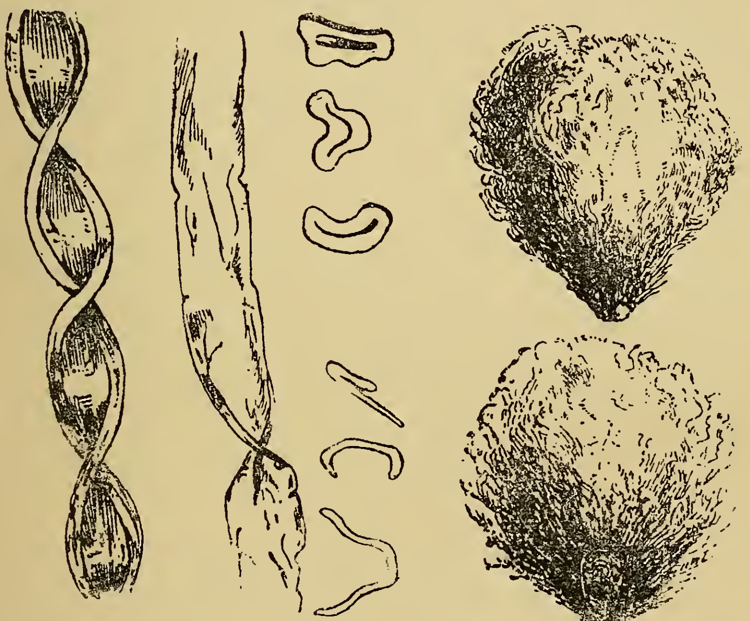

FIG. 1. FIG. 3. FIG. 4. FIG. 6.

of 2lb. seed to 1lb. fibre, is used up at the oil-mills—while the cotton is packed in bales of 4cwt. and forwarded to the sea-coast for export. The foregoing may be taken as a condensed description of the cultivation of cotton on an American plantation. In Brazil and Egypt the season is about a fortnight later; in India planting generally commences in July, or immediately after the dry season.

The raw fibre then is a ribbon-shaped filament with

corded edges twisted with 300 to 800 convolutions to the inch; thus, although to the naked eye appearing quite smooth, under the microscope it has somewhat of a resemblance to the shape of a joiner's auger.

Fig. 1 represents a typical cotton fibre about 400 times the actual size, and Fig. 2 represents its section. Fig. 3 represents an immature or imperfect fibre, one which is more transparent, brittle, and weak than the ordinary fibre, with no tendency to take dye. The convolutions also are few and irregular. Fig. 4 represents its section.

The longest fibre is the Sea Island cotton grown off the coast of the States, averaging $1\frac{5}{8}$ inches in length, and chiefly spun into 150's to 400's yarn, although for experimental purposes 2150's have been produced from it. Egypt gives three varieties—brown, white, and Gallini. The first-named is commonest and is used for 50's to 150's wefts and twists.

The American States yield a comparatively clean and even-running cotton, the best variety being Orleans, of a mean length of $1\frac{1}{16}$ inches, used for 30/40's T and 30/60's wefts. Texas, though shorter, is from its strength used for warp yarn, while the numerous varieties classed as uplands or boweds are suitable for weft on account of their usual good colour and cleanliness. The difference between the white 60's and 70's wefts and brown ditto is that the latter is from brown Egyptian cotton.

Brazilian is a very harsh fibre about average length, and used for twists either alone or mixed with American.

The East Indian varieties are extremely variable in length, and also in relation to the quantity of weak fibres; the properties common to almost the whole being brown colour, and dirty and rough character of the cotton. It is chiefly used in Rossendale, Bury and Oldham for coarse counts.

In the medium trade the fibre is subjected to no fewer than nine processes (each different, and sometimes duplicated or triplicated) before it arrives at the form of even thread known as yarn. In the fine trade two or three additional processes are added.

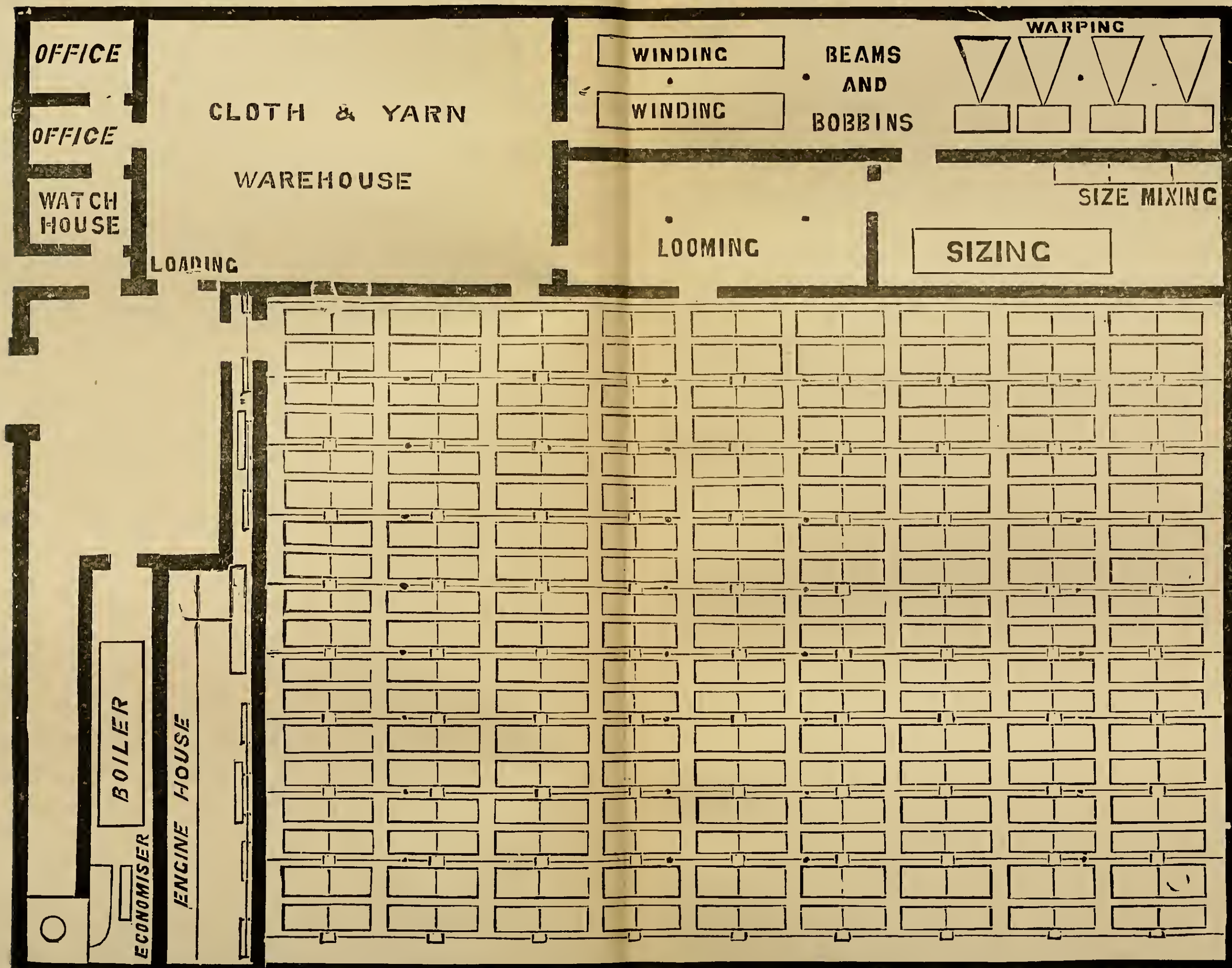

PLATE I.—PLAN OF SHED.

To face pp. 16 *and* 18.

The spinning department, to describe it briefly, consists of:—

1. *Mixing* the cotton in stacks to secure thorough blending of various qualities, and elimination of the unevenness present in different bales or parts of one bale. Then commence processes for cleansing, viz.:—

2. *Opening* or passing the matted pieces of the bales through a series of armed beaters having the functions of both separating the material into small flakes and removing the heavier impurities contained in it, such as sand and seeds.

3. *Scutching.*—In this process a wing beater, revolving at a speed of 11/1500 revolutions per minute, removes the remainder of the heavy dirt, delivering the material in the form of a lap or roll of cotton. This process is repeated.

4. *Carding.*—Here, by means of revolving cylinders covered with fine wire teeth, and combing the cotton against other cylinders or plates similarly covered, the light impurities—leaf, dust, short and weak fibres—are extracted, and the lap attenuated into a thin sliver, in which the fibres are laid in such a position as to be easily drawn parallel at the drawing process. These four kinds of cleaning machinery remove impurities and other matter foreign to the nature of cotton, to the extent of about 10 per cent., taking middling American cotton.

5 *Combing.*—The long fibres are here separated from the short, thus enabling a portion of the cotton to be used for spinning finer yarns than the bulk would spin. It is only in the mills spinning yarns above, say 80's, that this process is found; in ordinary, the custom is to go direct from carding to

6. *Drawing.*—A simple process repeated for yarn up to 30's, used three times up to 60's, and four processes are used above this. The machine has for its object the levelling of the slivers, six of which are placed together and drawn six times the original length. When this has been repeated once or twice, the sliver becomes very even and silky in consequence of all the fibres having had the curl taken out and been laid parallel to each other.

7. *Slubbing;* 8. *Intermediate;* and 9. *Roving.*—These frames are all constructed on one principle, and have for their object the gradual diminution of the thickness of the

sliver, which at these processes is attenuated so much as to require twisting to keep it from breaking at the succeeding process. An additional jack roving frame is used at mills making over 100's yarn.

10. *Spinning* completes the object of all the former machines —*i.e.*, to produce a level clean thread, free from unevenness in every respect.

Four sorts of machines are used for completing the attenuation—the self-actor mule, ring frame, hand mule, and throstle frame. The two latter are fast disappearing in consequence of the great improvements over the hand mule recently made in the self-actor mule, so as to spin fine counts up to 300's, and in the increased output of the ring over the throstle frame. The mule is automatic in all its movements for spinning the yarn and winding it on the spindle in the form of a cop—*i.e.*, a cylindrical coil of yarn, cone-shaped at each end. In this machine the spinning is intermittent—*i.e.*, for a few seconds the different portions of the machines are engaged in drawing out the roving to the required fineness until about 64 inches have been spun, the slack being taken up by a moving carriage bearing the spindles, then a few seconds are employed in drawing back the carriage and winding the yarn on the spindles. The ring frame is a constant spinner, and as fast as the yarn is spun it is wound on a bobbin, while the necessary twist is put in by a traveller shaped revolving round a ring. It will thus be seen that the ring frame is only suited for warp yarns, mainly in consequence of having to use a bobbin, which of course requires modifications in the shuttle and box of the loom, and even then is disadvantageous. The ring frame is suitable and preferable for warp yarn up to 40's, where the spinner also reels, warps or weaves his own spinning. The mule spins both weft and twist. Throstle twist (or, as it is called when reeled or warped by the spinner, water twist) is generally admitted to be the evenest and roundest thread, ring twist being next best, and mule yarn inferior to both. Mule yarn, however, possesses an elasticity which neither of these can boast of.

From a consideration of spinning we arrive at a definition of the manufacturing processes.

Unlike the spinning which is carried on in a building five or six storeys high, the manufacture of cotton goods takes place in a "shed," as much of the work as is possible being carried on on the ground floor. The weft yarn, or that which is laid transversely in the cloth, leaves the mule in the condition in which it is required at the loom, but the twist or warp yarn passes through several "preparatory" processes to fit it for the operation in the weaving:—

1. Winding—to take the yarn from the cop and place it on the warper's bobbin.
2. Warping or beaming to wind the yarn from 400 or 500 bobbins to one large beam.
3. Sizing—*i.e.*, covering the warp with an adhesive preparation to fit it for standing the strains in weaving.
4. Attaching the healds and reeds to the warp, called looming or drawing-in.
5. Weaving.

Each of these will be described more fully in succeeding chapters, and as in different districts different methods are employed, more especially in the sizing and beaming systems, the one chosen for most minute description will be the one used most commonly, although the other systems will be referred to.

The weaving mill—or, as it is termed, shed—requires description next. The general details of such a building will be more easily understood by referring to the annexed plan.

The most important point to remember in the arrangement of the rooms for the different processes, is to place each so as to require as little transit of material as possible. The engine, a condensing one of 110 indicated H.P., horizontal, is driven by the steam generated in a 30ft. by 7ft. two-flued steel boiler working at 120lb. pressure.

In the flue is fixed a set of economisers heated by the hot air and gases generated in the furnace, and through the pipes of which passes the feed water.

In the winding room are two 200 spindle machines (100 each side), keeping 12 winders employed. There are 3 beaming frames, 504 ends each. In the sizing department are found the usual becks and cisterns for mixing purposes, and one slasher sizing machine. It will be noted that the weaving shop has direct communication with the looming room where the beams are stored, and with the warehouse whence the weavers obtain the yarn, at the same time returning the manufactured material. There is also an outlet into the mill yard without passing through any other department.

In case of a new shed having to be built, many important questions present themselves for consideration. In fixing upon the site, the essentials for a suitable position are a foundation sufficiently damp and of such a nature as not to easily part with moisture, even in hot weather, so as to preserve that humid atmosphere so essential to good weaving, more especially where heavy sizing is resorted to; yet there must be no yielding, for it is of vital importance that vibration be reduced to a minimum, both in weaving, winding and warping, to avoid breakages of yarn.

As many readers will be aware, it is partially in consequence of this disadvantage being removed in mills entirely on the ground floor, and partially in consequence of the increased dampness thereby obtained, that such mills can obtain good results out of inferior yarns. A position in the neighbourhood of good workpeople is most important; such an advantage more than compensates for the increased rents, rates and other dues of a town as compared with a country district, for with inferior employés, inferior work, and therefore less advantageous prices and fewer orders, are a consequence, while the cost of production is increased. Good coal and water supplies are of importance, and are best obtainable in the vicinity of a canal, and if the district under consideration be a hilly one, it will be worth while considering how to be sheltered from that *bête noir* of a weaver, the east wind.

CHAPTER II.

WINDING AND WARPING, WARP YARN, WINDING FROM COP, BOBBIN AND HANK, BEAMING, SECTIONAL WARPING, BALL WARPING.

AS has been previously mentioned, the weft yarn, when it leaves the mule, is in the requisite form for use at the loom, whilst the twist or warp yarn passes through at least three processes to fit it for the operation of weaving. The object of these processes is to coat the yarn with a layer of the adhesive substance necessary to protect it from the chafing in the loom, and, secondly, to coil the threads of warp upon a flanged roller evenly, so that they will unwind at the loom in a level sheet the width of the beam, and containing the requisite number of ends to make a cloth of desired dimensions. Bearing this object in view, it is not difficult to understand the three processes—winding, warping, and sizing.

The Twist.

The warp yarn is generally received by the manufacturer from the spinners in skips of 200/250lb. weight, and in the form of a cop. This has a cylindrical formation coned at each end, the more pointed end from which the yarn is unwound being called the nose, the opposite end the cop bottom. The best Oldham spinners make the cop about $7\frac{1}{2}$ inches long and $1\frac{3}{8}$ inches in diameter.

In judging twist yarn preference is given to the most even thread, round and free from motes, soft places, and

snarls. The latter are caused by slack ends at the mule, the torsion of the thread taking up the loose yarn in the form of a twisted loop. A similar effect called a snick is caused by loose ends and inferior traverses at the winding frame, but wherever caused, the fault is most annoying to the weaver, and deteriorative to the cloth if intended for printing, as the loops rise after the cloth has received the impression of the pattern, showing white specks of an objectionable character. The twist cop should be of full dimensions, firm and hard copped, free from loose ends, and having clear apertures at the bottom for the winder's skewer. Any fault in these respects causes an increased percentage of waste—most objectionable to a manufacturer.

The selection of a yarn for profitable use depends upon the foregoing qualities, but care must be taken to select for heavy sizing an openly spun yarn; for lightly sized printing cloths a strong, well-twisted yarn; for sateens and velveteens a level one; and for other goods yarns suitable to them.

Winding from Cops.

The object of the machine shown on Fig. 7 is to wind the yarn from the cop to a bobbin of about $4\frac{1}{2}$ inches lift—that is, having a barrel $1\frac{1}{2}$ inches diameter, and a head or flange at each end with a space between of $4\frac{1}{2}$ inches.

The machine, Fig. 7, is duplex, having similar parts on each side of the frame; on each side will be observed two rows of spindles driven from a central tin drum by bands; five inches from the top of the spindle is fixed a braid bearing a flannel washer on which the bobbins rest, and are driven round by the friction; the cops are fixed in a spindle rail, the end from each passing round a knee board covered with flannel, thence through a brush which serves a secondary object of cleansing the thread from loose dirt, and tightening it so as to prevent snicks being formed. In front of this brush is fixed a guide plate, slitted to prevent the winder lifting the thread so as to pass lumps too large to go through the slits.

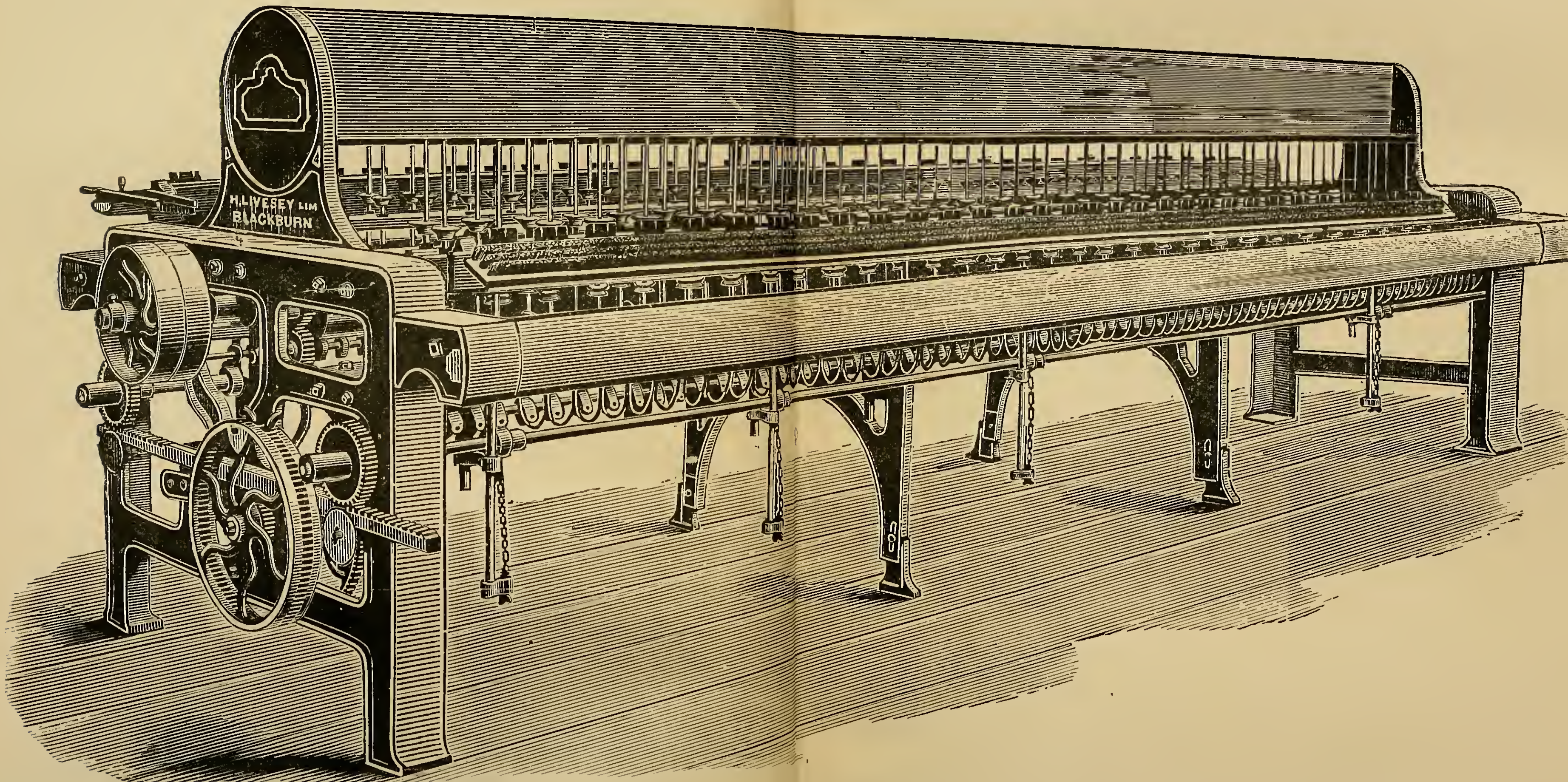

FIG. 7.—WINDING MACHINE.

To face pp. 22 and 23.

The brush and guide plate form a traverse, moving in slides alternately up and down to fill the bobbin with yarn, which is drawn from the cop through these "cleaners" by the friction between the bobbin and the revolving spindle. To enable a greater length of yarn to be wound on the bobbin, it is made of a barrel shape—*i.e.*, of greater diameter at the middle than at the ends. Although the first few layers appear parallel, a greater increase of diameter is noticed at the centre of the lift afterwards, simply caused by allowing a longer dwell of the traverse than at the ends of the bobbin.

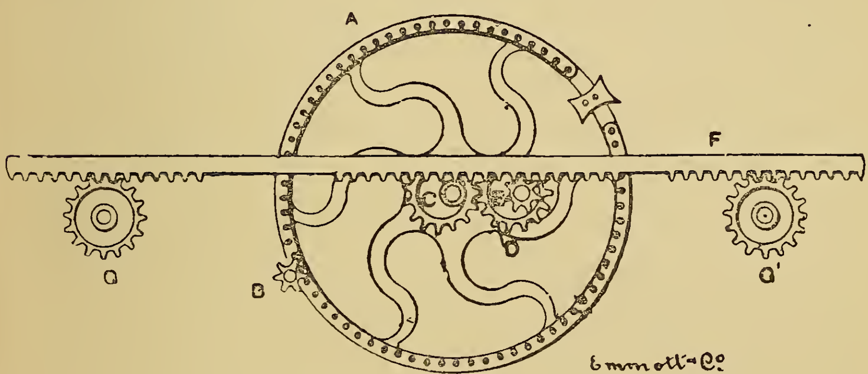

FIG. 8.

Fig. 8 shows an ingenious arrangement for obtaining the reciprocating motion, and at the same time the varying speed. A mangle wheel A is driven by pinion B, alternately engaging with the inside and outside of mangle wheel, thus reversing its direction of motion. On mangle wheel shaft a spur wheel C of eccentric motion gears with a similar one D on a stud, driving by a pinion E the rack F connected with the traverse. When the traverse is halfway of the bobbin, the mangle wheel is set opposite to the pinion B ; and the small side of the eccentric C driving the large side of D. It is quite plain, then, that by this setting of the eccentric wheels the traverse will be at its slower speed, while as the mangle wheel revolves

the larger side of C will drive D, and thus drive the traverse quicker as it gets near to the flange of the bobbin, and consequently nearer to its reversal. An exactly similar movement is obtained in another make of winding frame by means of a heart cam actuating a treadle, to one end of which is attached the traverse chain. As the larger or smaller part of the heart actuates the treadle lever, it is driven more quickly, while its normal speed is attained when contact is equi-distant between the apices. It will be observed that when the bobbin attains a larger diameter, even if the speed remains the same, the yarn is wound on more quickly in consequence of the bobbin's greater circumference, but the speed is also increased because of the additional friction generated by the increased weight. To obviate this uneven strain on the yarn, the back row of spindles is often made to revolve more slowly than the front one, and as the bobbin increases in size it is placed on the back row. Winding from either throstle or ring bobbins is performed on a similar machine, modification having to be made in the spindle rail only, so as to obtain a proper position for the bobbin to unwind itself, the yarn coming off the bobbin at right angles to it and causing it to revolve on the modified spindle. Occasionally, where a manufacturer possessing the cop winding frames uses ring bobbins, the yarn is unwound from them in the ordinary way over the nose of the bobbin, and a little additional drag is applied.

Winding is performed by women, who are remunerated at the rate of about $\frac{1}{4}$d. per lb. for 32's T, and proportionately more for higher counts. The most frequent fault in the shape of the bobbin is in its being soft near one of the flanges: often dirt gathering in the guides causes this, or the traverse is not set half-way of the bobbin when the mangle wheel crab is opposite to the pinion. Gigging is the name given to winding off any excessively large bottoms by means of a slowly revolving bobbin, forming part of the winding frame. The speed of the driving drum averages 160 revolutions per minute. The traverses should have all gatherings of fluff, motes, etc., brushed out twice a-day.

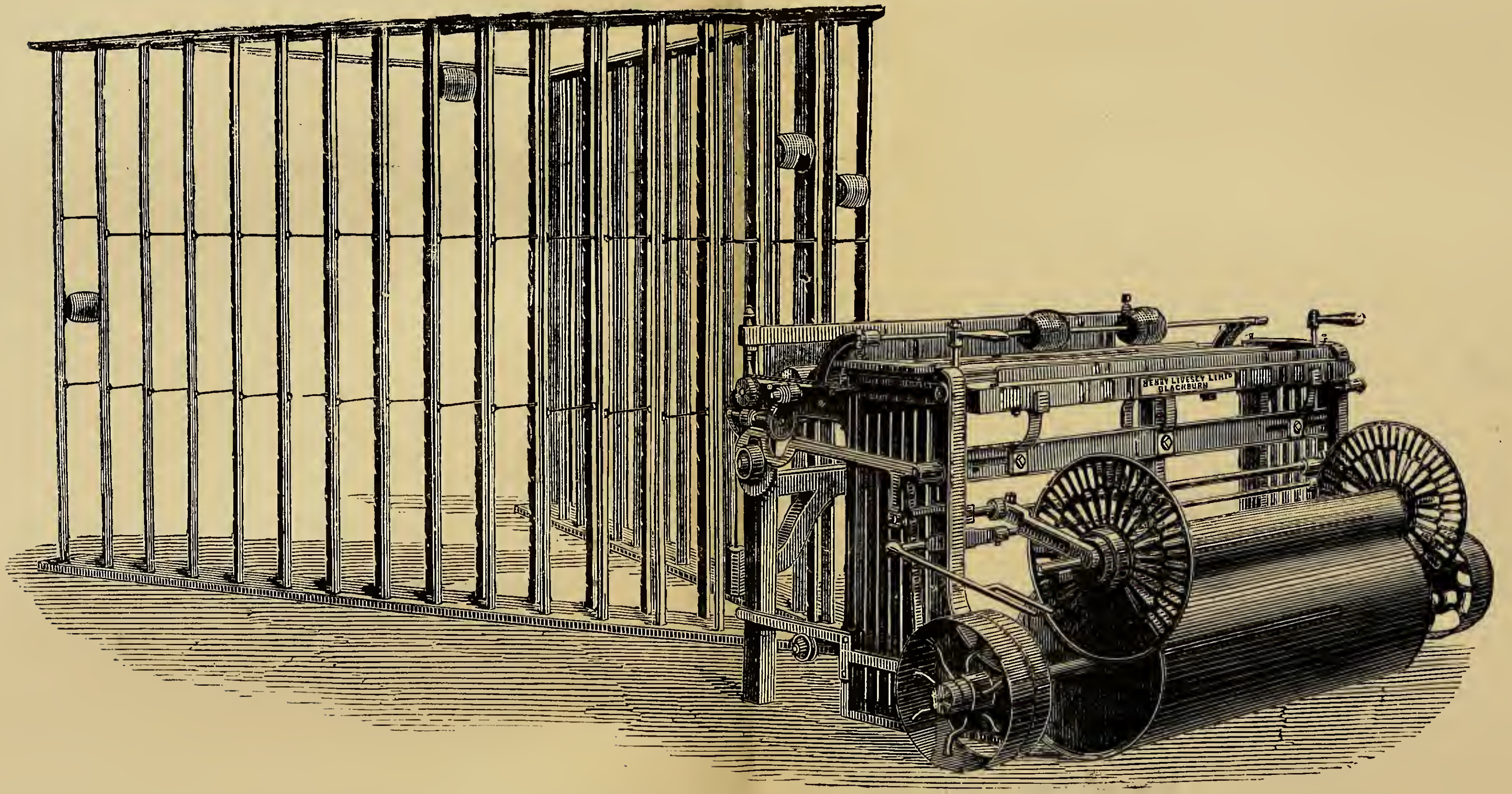

FIG. 9.—BEAMING FRAME.

To face pp. 24 *and* 25.

Winding from the Hank.

Coloured yarn used for dhootie and other striped cloth is received by the manufacturer in the hank, in which form it is dyed. When winding it on the ordinary bobbin for warp, only slight modifications of the winding frame are required. A swift is substituted for the spindle rail, and used for holding the hanks while unwinding them, while the kneeboard and brushes are absent. If the coloured yarn be used for weft for heading purposes, a pirn is substituted for the bobbin.

Other systems of winding have been introduced with only partial success, the principal one being a modification of drum-winding: a tube on which the yarn is wound rests horizontally on a revolving drum, the thread traverses the width of the drum, and thus a bobbin is built up, having level edges sufficiently firm without any protecting flanges. The ordinary drum-winding is similar, excepting that a flanged bobbin is used.

Beam-warping.

Three methods of warping are in use, but far ahead of the others in production stands the beaming system. To enable a sufficient number of threads to be gathered in one sheet for sizing purposes, say 2000, it is necessary to wind them first on a warper's beam. This is a round roller, of wood, five inches in diameter, having an iron flange 20 inches diameter, and also an iron pivot at each end. This will hold 500 ends, each 15,000 to 20,000 yards in length, so that for a cloth of 2000 ends four beams are required at the sizing machine.

The beam-warping machine is for the purpose of warping the yarn from these 500 bobbins to a beam.

The bobbins from the winding frame are placed in a creel, generally a V creel, and shaped in plan view as its name indicates, each arm of the V being a frame containing tiers of pegs to hold 250 bobbins, the apex being nearest to the frame. The yarn passes through a reed, under and over several horizontal rollers, emerging in front through a guide comb, and thence to the beam. The

beam is driven by friction, resting on a large drum making about 50 revolutions per minute; therefore, whatever the size of the beam may be—*i.e.*, whether full or empty—the yarn, being pulled at the front, is travelling at a constant speed.

To avoid sudden strains of yarn the creel does not rest on the floor, but is suspended from overhead beams by rods. The older makes of beaming frames have a bed creel. Only one vertical creel is used, the other half of the bobbins being fixed in a horizontal frame. The V creel is preferable.

The whole frame occupies a space of about 16 by 18 feet.

The guide comb is of interesting construction. It is capable of expansion or contraction. Each tooth of the comb projects from an iron box, and is kept in position by being passed through the coils of several spiral springs; by means of a screw and nut at each end these springs can be compressed, thus diminishing the distance between the comb-teeth equally at all parts of the comb. When the expanding combs are used, far leveller beams are made than are otherwise attainable.

In the event of a thread breaking, the warper must have some arrangement for running the yarn back, so as to find the broken end to piece it up. This is obtained by six falling rods placed above seven fixed ones. When the machine is running forward the sheet of yarn passes between the fixed and loose rods, the latter resting on a slide. When the machine is reversed, the slide receives a slight impulse, allowing one rod to drop, say $3\frac{1}{2}$ feet, the yarn being suspended at the top by the fixed rods; whilst this rod is dropping it pushes the slide still further, and another drops, and so on, until when the sixth rod has fallen, twelve times $3\frac{1}{2}$ feet equalling 42 feet of yarn are taken up. This is ample for piecing purposes; indeed, the woman in attendance seldom finds it necessary to go so far.

Prevention, however, is better than cure, and several machines are on the market fitted with stop motions to arrest the action of the machine at the breakage of a single end, and reducing the number of falling rods to two. One favourite system is to have a small bent wire, not unlike a

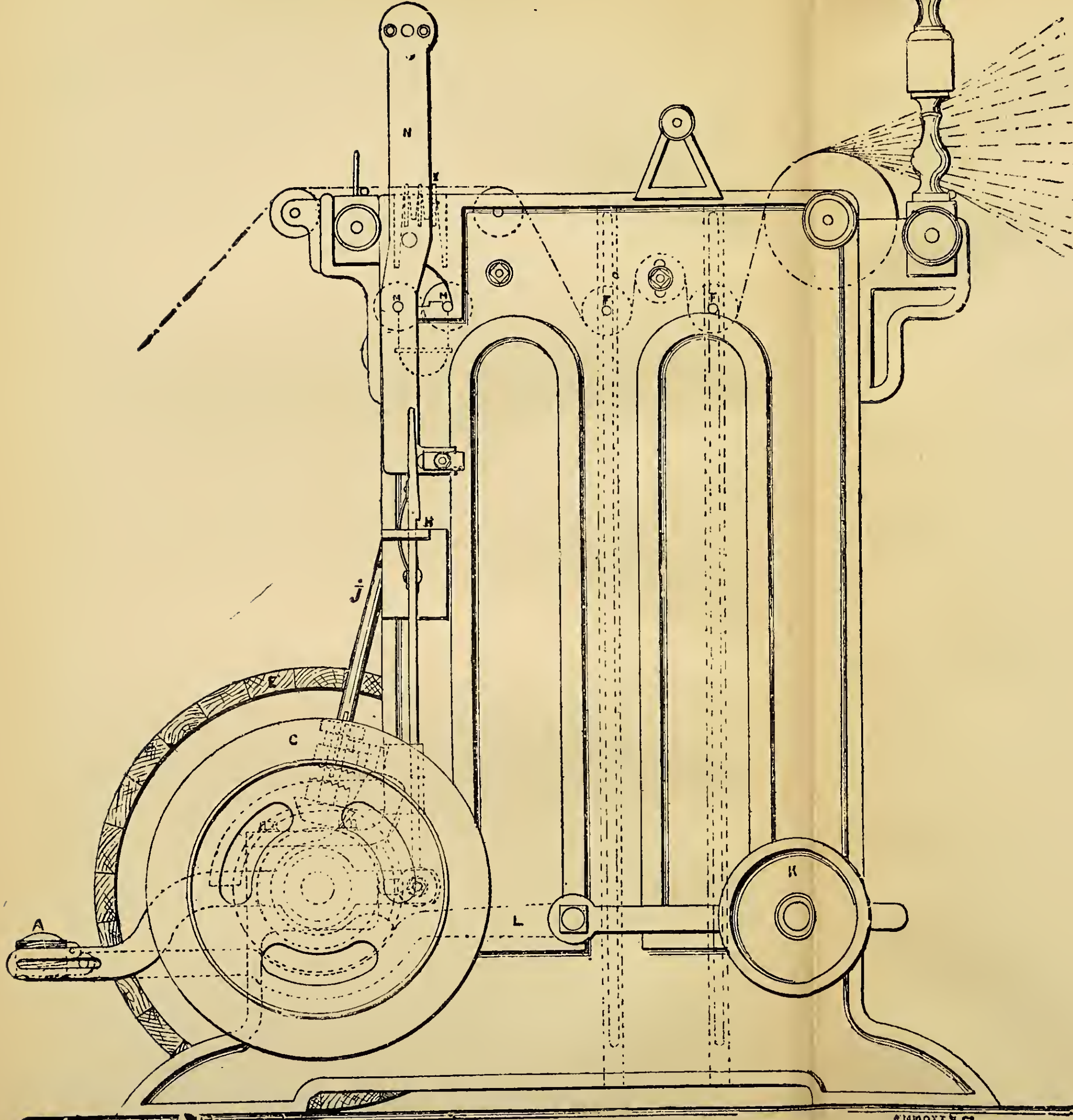

FIG. 10.

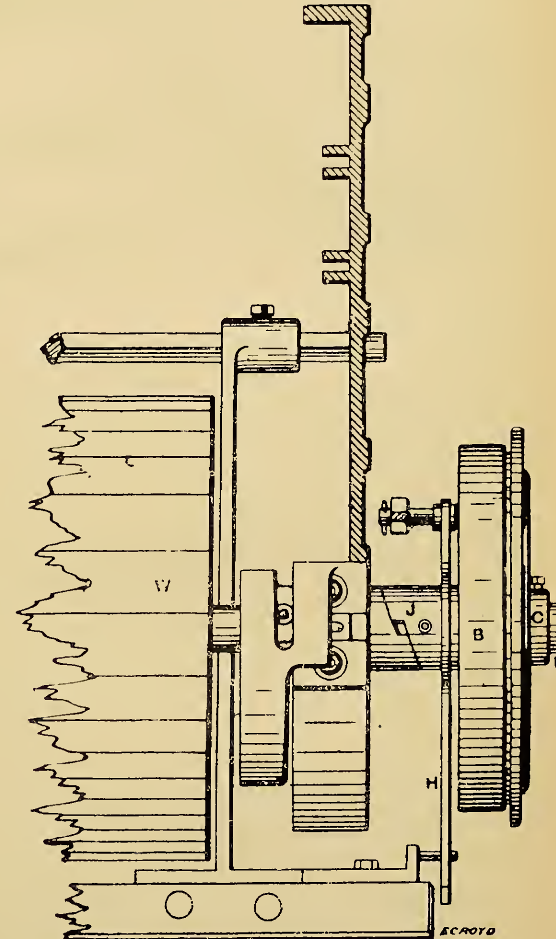

FIG. 11.

PLATE II.

To face pp. 26 and 27.

hairpin, but about $1\frac{1}{4}$ inch in length, suspended from each thread and held in position by slots across the frame. This system is shown in Plate II., Figs. 10 and 11. Immediately under these pins are two nip rollers M (Fig. 10), revolving in contact, one of them borne on a movable centre, and attached to an upright lever N. This is immediately above an upright slide I, the bottom of which is connected to one end of a lever centred on the drum shaft of the frame. At the other end of the lever is a foot board and also the connection of a long rod with heavy balance weight always tending to press the footboard up, and consequently the slide down.

The machine is driven by a single open strap on the pulley, which, however, does not actuate the machine until it is pressed against the friction plate.

To start the machine, the footboard is pressed down, the slide consequently lifted and held in position by a hook which catches on the framework. By an inclined collar J, on the centre of the lever H (Fig. 11), the friction pulley and plate are pressed into contact and the machine is in motion. When an end breaks, the hair-pin drops between the nip rollers, pressing the loose one away from the other, therefore by means of the upright lever already referred to knocking off the catch H (Fig. 10). As soon as this is done the slide drops, and with it the lever O. The inclined collar relieves the pressure on the friction plate and the machine stops. The attendant pieces the broken end which is thus brought under his or her notice.

Beam warping machines are of various sizes, the most common being for 504 bobbins, the width being 9/8ths, or 54 inches between the flanges of beam. Other widths, of course, are in use, from 44 to 108 inches.

The waste of yarn, in the preparatory processes, indeed in all departments of mill work, is extremely important, and should be kept at as low a percentage as possible. At the winding frame the total waste should be 1 to $1\frac{1}{4}$ per cent., varying with the count and quality of yarn, and the total waste of warp yarn throughout the mill should not exceed $1\frac{1}{2}$ per cent. at the most.

For the purpose of measuring the length of yarn on the beam, each warping frame is supplied with a roller half-a-yard in circumference, round which the yarn passes; on the end of this roller is a worm driving a worm wheel B, of 54 teeth; on the stud carrying B is a second worm C, driving a worm wheel of 132 teeth. The worm only takes one tooth at each revolution, therefore a complete revolution of the first worm wheel represents a length of 27 yards having passed the measuring roller; this is equal to one tooth only on the second wheel B; therefore, a complete revolution of the latter means 3564 yards—technically called a wrap—$\frac{1}{2} \times \frac{54 \times 132}{1 \times 1} = 3564$. If a warp contains 4 wraps and 7 teeth, it is 14,445 yards long $= 4 \times 3564 + 7 \times 27$. For other warping calculations see Chapter IX.

The faults in beams are principally, bad, or no piecings, soft places caused by fine threads, or ends unevenly distributed in the combs, or by crooked flanges.

Where dhooties and other striped cloths are made, the warper has to be provided with a sheet showing how the coloured yarn is "laid in" at the side. This will be described under the heading of Dhooties. Where possible, all the coloured yarn is placed on one beam of the set, leaving the other beams all "grey," as the undyed yarn is termed.

In any case of warping two counts of yarn on one beam, whether coloured or grey, allowance must be made for the different diameters of the threads.

Sectional Warping.

Where a warp is composed of two or more different counts of yarn, or where a ball warp is required without having recourse to the old circular warping mill, it is usual to use a sectional warping frame—Plate III.

As its name indicates the beam is warped in several sections called "cheeses," of the usual diameter, but only about five inches in width. Several of these sections are afterwards slid on a bar, compressed at the ends and treated in the usual way. If required to be made into a

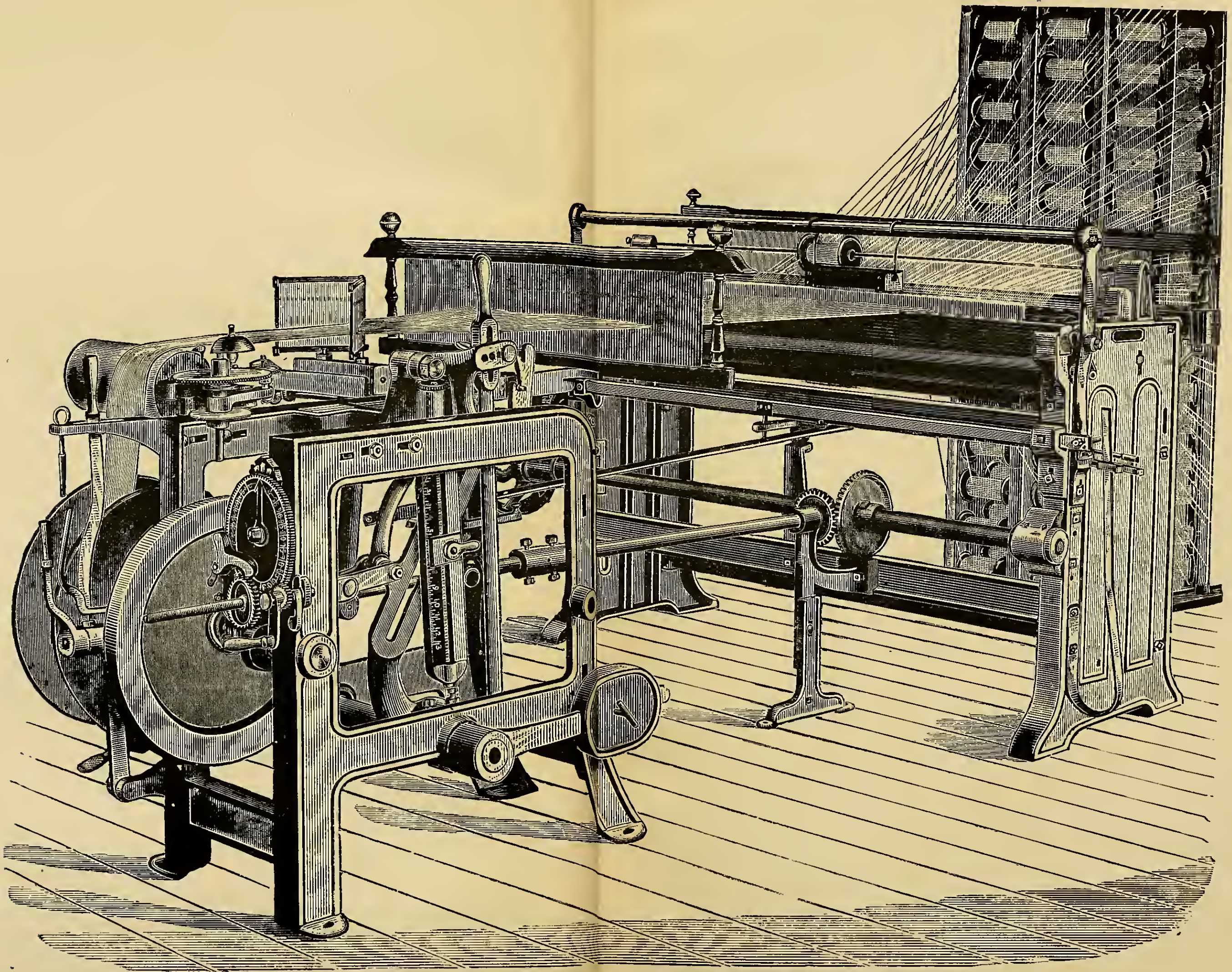

PLATE III.—SECTIONAL WARPING FRAME.

To face pp. 28 and 29.

ball, the ends are gathered into a loose rope and coiled in a balling machine. This latter method is generally adopted in those spinning mills where the yarn is warped by the spinner and sold in the ball. The sectional mill is a diminutive beaming frame of 400 bobbins running at a high speed. The yarn is warped on a square block between two circular plates, and when doffed is flangeless, thus necessitating careful treatment.

There is an interesting piece of apparatus attached to these machines for making all the cheeses of a uniform diameter when a certain fixed length has been wound on, and the increase of diameter is regulated automatically by the increment of length. The advantage of this is obvious when using two counts, say 30's and 40's, the warp in each case being, say, 1200 yards long.

If the diameter of warp were not regulated in any way, and the same strain placed on the yarn, the 30's warp would be of greater diameter than the 40's, or if of the same diameter the 40's would be softer.

To obviate this a standard cheese is made; and in making it, the attendant releases the setting lever, and allows the stud to move freely in the vertical slot. With it is also released the scale lever, and the other parts which control the presser. A required length of warp is wound on the section block, say the length of a cut, which is indicated by the measuring roller, and the movement thus made by the presser is shown by the movement of the stud in the vertical slot. The hand-wheel is then turned until the stud has returned to its former position opposite the recess in the back of the slot. The position of the nut is then noted on the front scale, and tightened up by the handle shown. The setting lever is now brought forward, and the stud resumes its normal position in the recess, and the setting operation completed. In order that each succeeding section may be the exact size and length of its predecessor, the only attention necessary by the warper is to see that the revolution indicator points to the same figures. Thus, when all are run off together, their sizes diminish at an equal rate.

This machine is taking the place of the warping mill in the cotton trade, especially for coloured work.

Ball Warping on the Warping Mill.

Before beam warping was invented, ball warping was the system commonly employed in the preparation of yarn for sizing. This is a somewhat clumsy method, and so far as the cotton trade is concerned has been superseded by a modern system, excepting in one or two cotton manufacturing districts situated on the borders of Lancashire and Yorkshire, and for certain classes of goods in Bolton. A brief reference to it will not be out of place then, although, probably, the subject may interest few readers rather than many. The warping mill consists of a creel for bobbins, and a large circular frame. These are of different sizes, a common circumference being about 18 yards. This framework, or reel, is about 10 feet high, and thus forms a somewhat extensive cylinder. About 500 bobbins (which are wound from the cop in the ordinary manner) are placed in the creel and the ends from each are gathered together midway between the reel and the creel, at what is termed the heck box. This slides vertically between two posts, and has for its object the correct guidance of the yarn to the reel and also the keeping of the lease. The latter term will be understood by all connected with weaving as being the separation of the threads alternately, an arrangement which is used to enable the position of the ends being easily found in succeeding processes. Supposing there are 504 ends in the creel, these would pass through the heck box, and forming a loose rope be attached to the top of the mill. This revolves, and as by suitable mechanism the heck descends, the warp is coiled round the cylinder spirally, making in all several hundred yards, say 350. When the bottom of the mill is reached the direction of revolution is reversed, and a second layer wound upon the first one, and a third layer on the second, thus a warp of (3 × 504) 1512 ends is made 350 yards in length. Of course, the dimensions of the warp may be varied either in length or number of ends. The warp is now unwound from the mill and coiled in the form of a large ball. In districts where ball-warping is still used, the manufacturer

is not usually his own sizer, and the warp, therefore, is now removed to a sizer's establishment, where, after being weighted to the required extent, it is coiled into ball form again and returned. In the few places where ball-warping is still used the warping mill just described has been superseded by the sectional warping frame, as the ends are kept straighter, and a greater length run through in the same time. The uneven lengths in the old ball-warping mill, caused by the outside layers being longer than the inner ones, are also obviated.

CHAPTER III.

SIZING MATERIALS, MIXING, AND MACHINERY.

IN a weaving mill there is no more important process than sizing, and on its satisfactory management depends the quality and quantity of work turned off, and probably the success of the concern. This is exemplified by the anxiety of a manufacturer to get hold of those recipes well known as obtaining good results. The sale of a shirting, domestic, drill, or heavily sized cloth, absolutely depends on the satisfactory sizing, whilst the cost of making it is regulated by the production of the looms. This has been known in many instances to vary 2s. per loom per week, in the use of a good mixing and a bad one. Cotton warp will not weave well without the previous application of some strengthening substance. In the loom the tension on the threads is great, and whilst distended—and therefore in the most favourable condition for being chafed—the healds with alternate vertical motion, and the reed with reciprocating horizontal motion, rub the threads so severely as to fray them to pieces, unless sized. This point was recognised and counteracted, even in the hand loom days, as mentioned in Chapter I.

In sizing, the objects are to press into the thread a mixture of suitable ingredients, so as to strengthen the yarn, smoothen it, and lay the fibres which project from the surface of the thread, thus increasing the strength, and at the same time reducing the amount of fluff at weaving; also to give to the yarn and cloth the requisite appearance of toughness, strength or body, known technically as the "feel." It is in the sizing that the "boardy," "leathery," "clothy" feels or grip are produced.

Another very important object of this process is the introduction into low classes of cloth of an additional weight of foreign substances. We have not here to deal with the debated and debateable point of its honesty or otherwise, but how the object may best be attained; so long as heavily sized pieces will be bought, so long will they be made, and no blame can, at all events, be attached to the manufacturer. He profits not by the weight, unless unscrupulous, for the price obtained for the piece of cloth is not based on the total weight, but on the amount of cotton contained in it. Frequently the state of the market allows a greater profit out of pure sized goods.

The percentage of size put on cotton goods is calculated according to the increase of weight on the warp only. Thus if the warp in a piece of cloth be composed of 10lbs. of cotton covered with 4lbs. of size, the warp will have been sized to the extent of 40 per cent. The amount of size on cotton warps varies from 3 to 200 per cent. In those classes of goods which are intended for dyeing or bleaching, and which are generally sold by the counts of yarn, it is obviously not wise to add foreign matter to be washed out again, but in those exported goods which have to be made of a fixed weight, or certain feel, heavy sizing is adopted. In the chapter treating of cloths, fuller information on this point is given. Up to 20 per cent. are termed light sized goods, from this to 50 per cent. medium, and above 50 per cent. heavily sized.

Yarn for Warps.

The selection of suitable yarn is obviously important. Warp yarn is generally stronger than weft, and the hardness is obtained by extra twisting of the thread: owing to this peculiarity, warp yarn is generally called "twist." For heavy sizing purposes, a soft spun twist is advisable, and one made out of the harder and wiry stapled cottons. Brazilian is of this character, and is often mixed with American for "shirting" warps. The spongy and size-absorbent properties are obtained at the expense of the strength of the yarn, and therefore a good sizing twist

often winds badly. The colour of the warp yarn is not important, and therefore whiter cottons are often reserved for weft. Fine twists are spun out of longer and finer cottons forming a close spun thread, which is used for better classes of cloth lightly sized. Strength and elasticity are great advantages in twist, and these properties should be obtained and preserved for the last process of weaving.

Sizing Materials.

Many points distinguish a good size-mixing from a bad one, and the leading qualifications for a suitable one are adhesive properties—it is no use sizing warps if the substance falls off at the loom—good colour, and uniform consistency. Mealy cloth is often produced by lumpy size. Yarn, even with a heavy coat of size, should remain tenacious, pliable and smooth.

The number and variety of sizing substances render it impossible to adequately describe the properties and use of each. Mention is only made of those of greatest use and importance; yet the list is sufficiently long. They may be divided into four classes—those for forming the basis or body of the mixing or adhesive substances, those for rendering the dried size pliable, weight-giving substances, and antiseptics. In the adhesive substances, *flour* is of first importance for medium and heavy sizing. This is manufactured by grinding a portion of the wheat grain, and the qualities used in sizing are of the better sort, fully equal to those used for bread-making. For giving body and adhesiveness to the size, flour is valued, but is found a rather expensive substance, and rather inclined to mildew. To remove this latter disadvantage, and also to render flour more suitable for the purpose for which it is intended, most manufacturers steep it in water for periods varying from three days to as many months. Practical men and sizing specialists generally agree, however, that from two to three weeks is the best length of time for fermentation. On judging the quality of flour, comparisons of colour and stiffness after boiling are made; in the latter case

equal quantities of each sample should be taken and treated similarly, both as to amount of water taken and time allowed for boiling. The best test, however, and one that applies to all sizing substances, is whether it "goes far" or not in actual use.

Farina is the ground starch of the potato, and largely used in light sizing on account of its cheapness and convenience for mixing. It requires the use of a softener with it, generally tallow or wax, to counteract a harshness which it gives to the twist when used alone.

Two other vegetable substances—sago and rice flours—are used for very light sizing, especially for fine reeds or coloured work.

Softeners.—Unless some ingredient with a more or less greasy nature be mixed with the above substances in sufficient quantities, the warp is so brittle and harsh as to break frequently in the loom. The substance most frequently used is tallow (refined animal fats). This is somewhat expensive, yet its softening properties in heavy sizing are often introduced into the mixing. The quantity of tallow to each bag of flour or clay varies according to the quantity of other softeners used. In using tallow care must be taken to obtain it hard and free from grit; much wear of clacks and rams may be attributed to gritty matter in this and other ingredients, especially in china clay.

Wax is a softener used for light sizing with farina. It is of two kinds: Japan wax, a vegetable substance, of rather yellow colour, and paraffin wax, clear and semi-transparent, obtained from mineral oils. A high melting point of wax is a great desideratum, to ensure the mixture hardening thoroughly on the warp—110° is considered a fair temperature for wax to bear before melting. For softness, castor oil and glycerine are occasionally adopted, as is also Irish moss.

Soap.—A mixture of animal and mineral substances is not generally used, although a good softener, its frothy nature when boiling rendering it difficult to deal with. Soap and chloride of magnesium (so called anti.) should not be used together, as their action on each other tends

to make the size lumpy. One important property of soap, or rather alkali contained in it, is that it kills any acid developed in the mixing. Soda has a similar and stronger tendency. Chloride of magnesium, muriate or chloride of zinc have softening properties, but those substances will be more fully mentioned in the next group.

Weight-giving Material.—Next to flour no substance enters into heavy mixings in such quantity as *china clay.* This is a white earthy matter found in Devon and Cornwall. After having all stony substances washed out it is dried and packed in bags for shipment to Runcorn and other small ports in the neighbourhood of cotton manufacturing districts. In selecting good qualities, colour and smoothness should be borne in mind. To use this material to advantage a good knowledge of other materials is required, so that such ingredients may be used with clay as to keep the size on the yarn at the loom. When clay is boiling it is somewhat dangerous to lift up the lid of the boiling beck, this substance having an unpleasant property of spurting up, possibly on the face or hands of an attendant.

Metal size is that containing the chlorides of the metals, magnesium and zinc. Chloride of magnesium, a mineral salt obtained in Germany, is valued as a weighting and softening compound. It has the peculiar property of attracting moisture to itself, always causing cloth or any substance containing it to feel damp. This substance is melted out of its solid form into a liquid by the application of steam, and is afterwards stored in a lead-lined tank. Muriate of zinc, or chloride of zinc, is a substance of importance for weighting, and is also valuable in checking the growth of mildew.

Mildew, as may be seen under a microscope, is a species of fungus—a vegetable growing under certain conditions favourable to its development. If warp or cloth is sized or finished damp, then stored in a dry room for a considerable time, mildew may be expected, unless antiseptics have been used. An antiseptic is a substance tending to destroy vegetable life, and of antiseptics muriate of zinc and carbolic acid are the most suitable for sizing

purposes. As chloride of magnesium does not prevent mildew, indeed, its use being rather favourable to the development of that evil, the name anti, or antiseptic, usually given to it is misleading. It is very important that a manufacturer should take every precaution to prevent mildew by the use of real antiseptics, especially when using such sizing materials as flour, tallow, or any other which readily mildews. It may be mentioned that the maker of the cloth is liable for any damage done in this respect, if the cause can be found in defective sizing, even though the growth may not be seen until the goods have arrived abroad.

The before-mentioned chlorides are greatly dependent on the weather, and also on the situation of a shed, for their good weaving properties. In case of east winds, extremely dry or cold atmospheric conditions, or in a dry shed twist sized with magnesium, zinc or china clay, is rendered brittle first. Numerous other materials are used by a few manufacturers, but they do not require an extended notice. Dividing them into the four classes previously mentioned, we may refer to:—1st, maize, starch, tapioca, dextrin, and gum; 2nd, oils, compositions, spermaceti, curd soap, Irish moss, cocoanut oil; 3rd, French chalk, Epsom salts; whilst soda is used to prevent iron-mould, and blue to take away a yellow tinge from the size mixing.

Size Mixing.

Mixing is performed in becks—wooden tanks fitted with dashers, constantly revolving and stirring the mixture. To each beck pumps are attached so as to force the size to another beck to complete the mixing process; or, if the mixing is ready for use, to pump it to the size box of the slasher frame.

A set of becks generally consists of four—two about 4 by 8 feet, and two each 4 feet square, while for heavy sizing a copper or copper-lined boiling pan is used. This latter is fixed at a higher level than the becks for convenience in transferring the boiled size to the becks.

Considering that a mixing made from a fixed quantity of certain ingredients is not generally used for percentages ranging more than 15 per cent., and that different mixings are required all the way up to 150 or 200 per cent., whilst at the same time not more than two or three manufacturers may use exactly similar mixings even for the same degree of weighting, it will readily be seen that the mixings employed in the cotton trade are innumerable. This difference has been caused by the jealous care taken by a sizer to preserve to himself the recipe of his own mixing, and rightly so. Thus, new mixings have had to be adopted by new firms, the correct quantity of each ingredient having to be fixed by repeated experiments; and as the true properties of each substance have not been, and are not yet, well understood among manufacturers according to scientific investigation, the differences of opinion, and consequent differences of recipes, are very great. Nor is it to the ingredients that these opinions are confined, but to the order of putting each into the beck, the times of fermenting and boiling, and many other details.

It is somewhat difficult to satisfactorily determine beforehand the amount of weight which can be obtained from a mixing. An instrument, really a hydrometer, but often, from the name of its inventor, dubbed a "Twaddle," is sometimes used; but unless a fixed temperature is always taken, these instruments are not reliable, as a mixing twaddles differently at different heats. Indeed, from the varying results obtained, a twaddle cannot be said to be of much practical use in sizing. A better system, perhaps, is to take the proportion of solid or semi-solid matters in a mixing as against the weight of water, and compare it with the ratio of another mixing which is known to give a certain percentage. Thus, if one mixing of 3lb. of solid matter to a gallon (10lb.) of water gives 25 per cent., then a mixing with 6lb. solids to the gallon may roughly be said to put in 50 per cent. Heavy liquids, such as zinc and solution of magnesium chloride, will have to be reckoned partially as liquids, in consequence of the evaporation which will take place on drying at the cylinders; and the softeners, from their

inability to retain liquids as well as the starches, will not be calculated as having the same weighting power. Magnesium may be reckoned as having one-third of its weight in solids, and zinc at one-half.

For Light Sizing.—Taking a pure size, say 8 to 10 per cent., farina and wax or tallow is generally used as being the cheapest, and at the same time most suitable mixing. The ingredients are generally combined in the same beck that they are boiled in; for 10 per cent. the following may be used: 200lb. farina, 20lb. wax, 200 gallons water. By the addition of clay, the same may be made serviceable up to 25 per cent.

For Medium Sizing, say 50 per cent.—Flour, clay softener and chlorides are used—say flour 480lb., clay 224lb., tallow 60lb., chloride of magnesium (so-called anti) 5 gallons, zinc 2 gallons, soda 8lb., water 150 gallons in all. It is mixed as described for 100 per cent.

For 100 per cent.—1lb. of size for 1lb. of warp. Similar ingredients are used, but different proportions. Flour 560lb., clay 560lb., tallow 130lb. (or other softener), chloride of magnesium 20 gallons, chloride of zinc 10 gallons, soda 10lb., and blue.

The flour is steeped alone for three weeks, at the end of which time the zinc is added to it with soda and boiled, then the other ingredients, which had been previously heated in the boiling pan, are lowered into the flour and the whole boiled together.

For 150 per cent. put still more clay and magnesium to the same quantity of other substances, adding some specially prepared softening grease, or adhesive size mixture.

The mixing of size requires constant care and supervision; for variations in the quality of materials, in the weather, or in time of storage or steepage necessitate changes in the proportions of ingredients to obtain correct and unvarying weights.

Sizing Machinery.

The slasher is the machine generally used for applying the size to the yarn; the usual name for the process is

taping, a word derived from the old tape frame in use 30 years ago, and handed down to its successor, the slasher. One sizing frame is required for 300 looms, the width of the frame being adapted to the size of beam required for the loom; this is a few inches wider than the cloth. A common size is a 9/8; this makes warps 54 inches wide between the flanges, the drying cylinder face being 60 inches wide; a 6/4 is 60 inches beam and 66 inches on face; an 8/4 = 78 inches and 84 inches respectively.

A sizing frame is of great length, and in three portions—at the back the creel, in the centre the drying, and in front the headstock. (See Plate IV.)

Supposing a warp is required of 2480 ends—three beams, each 504, will be taken together with two of 484 each; these are placed in the creel in two levels, and the narrower ones are placed at the back. If they were in front of the broader ones the sheet of warp would overhang the narrow beams. The ends are gathered in one sheet, the layers from the hinder beams passing over the top beams and under the bottom ones, all leaving the creel after passing under the foremost beam and travelling into the sow box. Two contiguous boxes or troughs are used for holding the size—the one farther from the creel, called the size box, receiving the mixture directly from the beck, a regulating valve being fixed on the inlet pipe to prevent the box becoming too full. The sow box is the larger one, and receives the size from an aperture in the bottom of the size box, as well as from a separate pipe. In the bottom of the sow box is fixed a boiling pipe of elliptical form, perforated with small holes, through which steam is forced into the size, causing it to boil, and thus always be in the fittest state for application to the yarn. At about half the height of the box two pairs of rollers are fixed, the back pair having the bottom one of wood, and the top one of iron, covered with flannel and cloth; the front bottom roller, or finisher, is of copper, having resting on it a heavy iron one, likewise covered with several layers of flannel and two of cotton cloth. On the firm and even surface of these rollers depends, to a great extent, the quality of the sizing. Between the

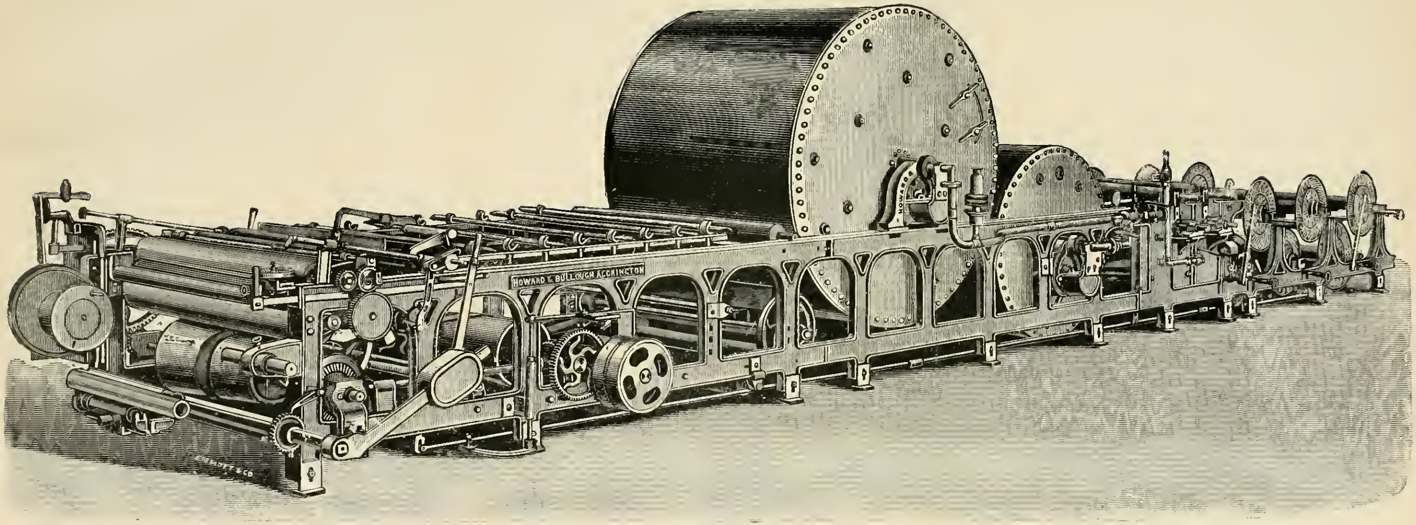

PLATE IV.—SLASHER SIZING MACHINE.

To face p. 40

wooden roller and the end of the box nearest the creel is a copper immersion roller, its use being to lower or raise the warp in the size by means of a rack and pinion. The warp ends coming up from the beams pass under the immersion roller, thus being soaked under the surface of the boiling size, thence between the first and second pairs of rollers—the object of these being to press out all superfluous size and imbed into the thread that which is required. Immersing the thread deeply is advantageous for heavy sizing, although, by simply dipping it, the fluid only attaches itself to the outside of the thread. Better results could be obtained by pressing the yarn whilst under the surface. An example of the hollow india-rubber ball illustrates this. If a punctured or slit ball be immersed in water, without pressure, little or no fluid enters it; but if, whilst under, it is squeezed, the air is expelled, and, on expanding, the surrounding water enters, filling the cavity. Similar results can be obtained by expelling the air from the interstices of the yarn whilst under the size, and patents have been taken out for suitable apparatus. This point is worthy the attention of machinists. Unless well boiled, size retains a granular nature, causing faulty cloth; to obviate this, many machinists insert between the size beck and the sizing frame an extra boiling apparatus, so arranged by the intervention of pipes to boil the size under pressure, impinging steam against the particles of size as they enter the box, thus breaking the globules. After boiling thus, the size enters the box in the ordinary way. To lay the fibres on the yarn a few sizers have recourse to revolving brushes acting on the thread directly after passing the finisher roller. These revolve about 700 revolutions per minute, considerably faster than the warp speed. They are considered advisable for fine reeds and fancy goods.

Adverting to the process of sizing the warp, we come now to the drying; this is done by means of two tin or copper cylinders about 7 feet and 4 feet diameter respectively, the larger one being nearer the front of the frame (see Plate). Steam at a low pressure is admitted to

these, and both are enclosed in a wooden case. The sheet of warp passes over the smaller cylinder without touching it, and round the larger one; leaving this at the bottom, the twist is next led over the small cylinder and passes to the front of the frame under both. Thirteen or fourteen yards of warp are always drying. Although the moisture has been expelled, the twist is now in a very hot state, and on its passage into the headstock a couple of fans are used for cooling purposes. Systems of drying by currents of air have been introduced, but seem to take no hold in the cotton industry. It is important that the surface of the drying cylinders be kept smooth.

The headstock of the slasher consists of framework, holding the rods and reed necessary for separating the sized threads, and the apparatus for winding the yarn on the weavers' beam. This latter operation comprises the driving of the whole machine, as all the actuating power is transmitted from the headstock by the pull exerted at the front of the machine. By iron rods the

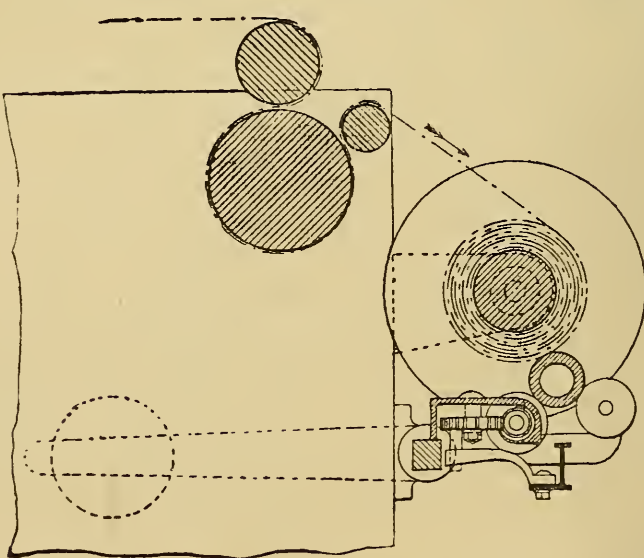

FIG. 12.

sheet of warp is repeated horizontally into as many layers as there are back beams; then, by means of an expanding comb, the rods are separated vertically; thus

each being sundered from its fellows, no possibility of "sticking" remains. The split rods are shown in Plate IV.

The most effective mode of winding the yarn on the beam is shown in section at Fig. 12.

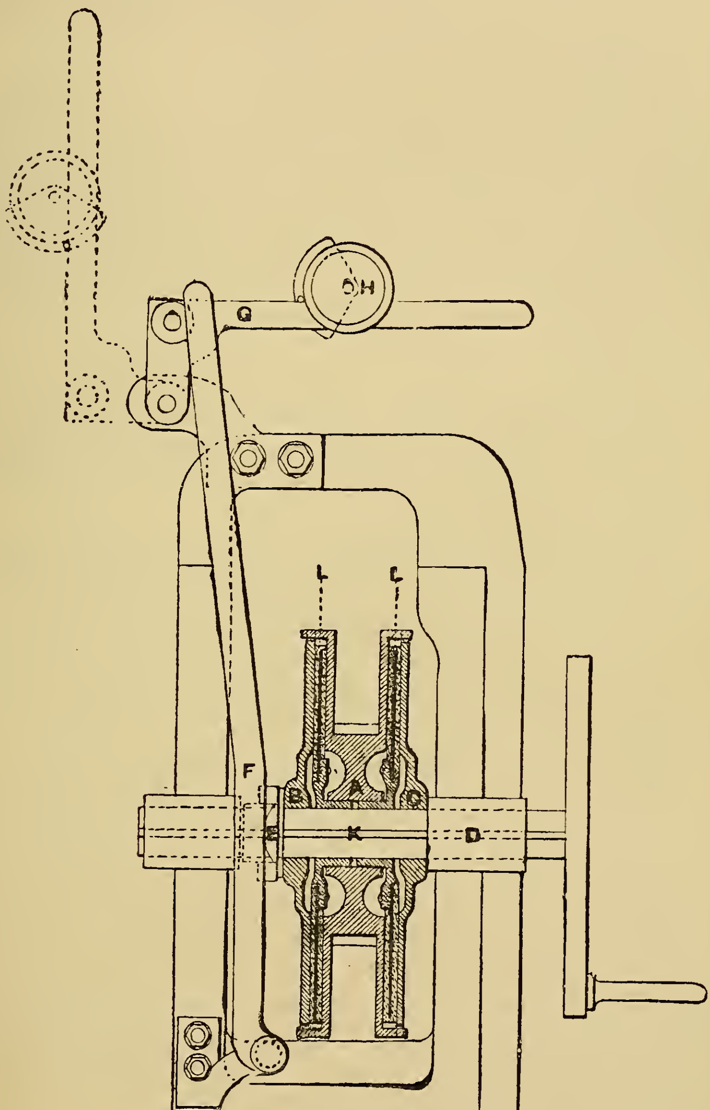

FIG. 13.

Power is received by the main shaft carrying the cone drum, and transmitted by a strap cone drum; this in turn

drives by a pinion the wheel fixed on the friction roller (the largest of the three rollers at the upper part of Fig. 12), which is thus positive driven. It also drives the beam shaft, but not positively; the only connection between the ccg wheel A, Fig 13, and the shaft on which A rides loose, is by means of the friction plates L, between A and B, and A and C.

Unless these are compressed so as to clip a felt washer, the beam is not driven at all, so that it is very easy for the sizer to regulate the tension at which his yarn shall be wound by moving the weight H on the lever G, which presses the positive driven plates B and C against the friction driven plates L L, bringing them into closer contact and thus speeding the beam, consequently tightening the yarn.

The friction roller is a shade larger in diameter than the finishing roller in the sow box, and is connected with it by a long side shaft, each roller revolving at the same speed; the yarn is consequently kept sufficiently tight during the whole process.

In the old style of frame, without the above-mentioned friction, cone drums were used for regulating the speed of the warp. As the beam increased in diameter, one revolution meant a greater length of twist wound on, and the strap had to be moved along the cone drums to diminish the number of revolutions of the beam per minute, and thus keep the speed of the sheet of warp constant.

Numerous presses are used to get a hard beam with a greater number of cuts on it. Although, when extremely hard, the weaving is more difficult, the advantage of fewer gaitings of beams in the shop, doffings at the size frame, and less waste is adequate compensation. These presses generally consist of one or two rollers resting on a stand under the beam in the frame. By weighted levers the stand and rollers are forced upwards against the beam, and keep it hard whilst winding. Figs. 14 and 15 represent plan and section of this presser.

The duties of the slasher, or, as he is more frequently called, the taper, are to keep the size of proper boil and density, so as to obtain a constant weight of cut, to keep the twist pieced, and doff the beams when filled. In some

operations it is necessary to stop the frame for a few minutes, and although the stopping handle is connected with the cylinder steam pipe to prevent further admission of steam to the cylinders, these remain so hot as to brown the twist.

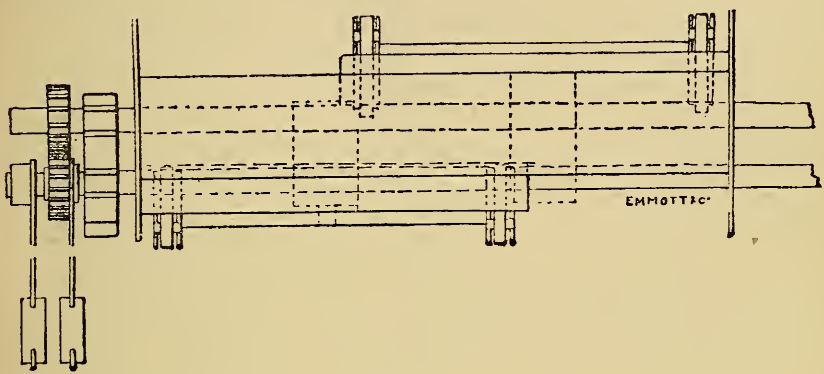

FIG. 14.

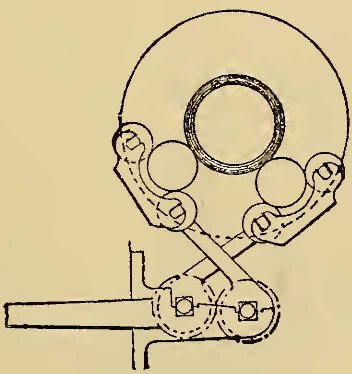

FIG. 15.

Slow Motion.

A slow motion is usually fixed on new frames, and as will be seen from Fig. 16, it is a simple and effective method for preventing brown or hard places in the warp by running the machine very slowly instead of stopping it completely. A thin pulley rides on a collar on the main shaft of the frame, and by the gearing shown (Fig. 16) drives the driven cone far slower than its usual speed. Obviously

the fast and slow motions could not be both connected with the driven cone by fixed gearing, and consequently, to enable the slow motion to be put in gear only after the

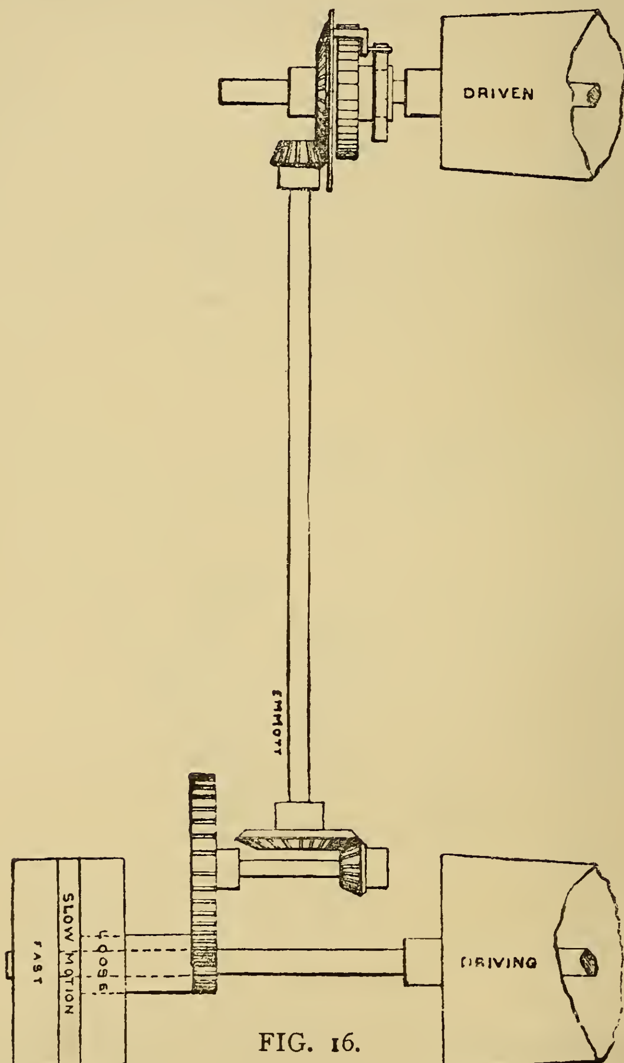

FIG. 16.

fast speed is out of action, the shaft only drives a plate carrying a ratchet pawl. The ratchet wheel is on the driven cone shaft, and as the pawl only overtakes the wheel when the latter is almost stopped, the desired end is obtained.

Marking Motion.

To enable the weaver to finish the piece when a required length has been woven the warp is marked at the sizing frame at a certain length. This is generally done for plain goods by means of a measuring roller 14·4 inches in circumference, round which the twist passes. On the end of this is a tin roller wheel driving a change wheel or stud wheel. By means of a worm on the same stud the motion is transferred to a bell wheel of 45 teeth, which drives a marking cam so arranged as to gradually lift and suddenly drop a hammer, which smits the warp against a block soaked in some colouring matter.

To get the wheels for a certain length, say the stud wheel, multiply the length of mark desired in inches by tin roller wheel, and divide by the bell wheel and the circumference of tin roller.

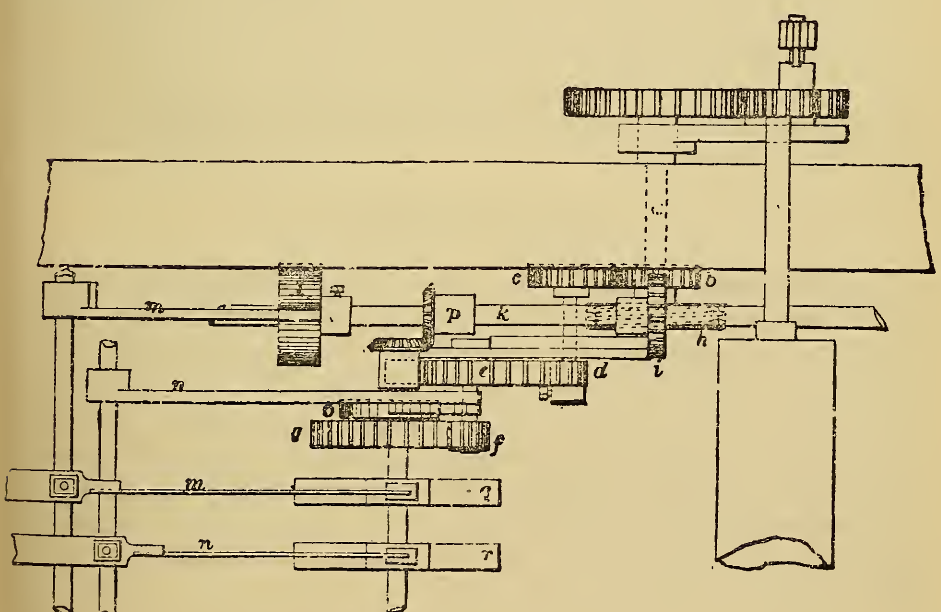

FIG. 17.—DHOOTIE MARKER.

To get the tin roller wheel, multiply the circumference of measuring roller by bell wheel and by stud wheel,

dividing by length of mark required. To prove this the length of mark may be obtained from the wheels, say stud wheel 105 and tin roller wheel 45.

$$\frac{14 \cdot 4 \times 45 \times 105}{45} = 1512 \text{ inches, or } 42 \text{ yards.}$$

In marking dhooties, in addition to the smit for the end of the piece, additional smits have to be made where the heading for each scarf has to be inserted. Usually this is done by having an additional train of wheels and an extra marker, called a dhootie-marker, to strike 3, 4, or 6, etc., times for the cut-marker's once. In Fig. 17 a special arrangement is shown. The usual wheels are shown at *h*, the worm *i*, the bell wheel *k*, the bell shaft cut-mark hammer *m*. The other wheels and the marker *n* refer to the dhootie mark; *b* is fixed to the stud and drives *c* with *d*, a pinion on another stud; the wheels *e*, *f* and *g* complete the train, and on the same shaft as *g* a cam *o* operates the dhootie-marker. This is arranged to strike any number of times for once of the cut-marker, regulated by the number of teeth in the change wheel *f*, 10 teeth in which give one mark to a cut mark, 30 give three marks to a cut, 100 ten marks to a cut, and so on by somewhat similar systems for higher numbers.

Tape Dressing.

The tape dressing machine—the predecessor of the slasher—is still used in Scotland, being suited to the light fabrics principally made there. The back beams are placed in a creel at one level and the ends pass through a reed at the back of the frame. The sheet is then immersed in size, and passes between a pair of slowly revolving circular brushes, afterwards being dried by a fan, and also on a small cylinder. There is no friction, and the yarn is wound on the beam after being split by the rods and reed.

Ball Sizing.

Only one system of sizing in addition to those referred to requires description, and that is ball sizing, the process

following ball warping, described in the previous chapter. The warps are uncoiled from the ball, and run into a large vat of size, at the bottom of which the warp remains some time, passing over and under some eight or ten rollers until thoroughly soaked. The superfluous size is expelled by passing the warp between rollers, when it is removed to another machine for drying purposes. This has 12 cylinders 2 feet in diameter, and of considerable width, heated by steam. Between these cylinders the warp is flattened and dried, after which it is again balled and placed in a cloth for a short time to become "mellowed;" even yet it has one process to undergo—beaming. Here the warp is taken, the ends sundered out and run over a frame to the weaver's beam. The reader will readily see that the extra processes of balling after warping, and beaming after sizing, as well as two machines required *for* sizing, are sufficient to explain the fact that ball systems are dying out, and not only for this reason, but also because of the uncertainty as to what extent goods can be weighted, the percentages being very irregular. The warps are often streaky also, but the thread preserves a rounder and stronger formation than at the slasher frame.

Looming and Drawing.

The weaver's beam, as made at the sizing frame, contains from 500 to 1000 yards of warp, according to the counts of yarn and number of ends. It is not yet ready for the loom, as the healds and reed have to be attached. If new healds and reed are used each end must be drawn through an eye of one of the healds and through a dent in the reed. In this case the operation is performed by a drawer-in, who, with hooks at one side of the gears, draws the ends through, which are presented to him by a reacher at the opposite side. In case of healds having been used before with similar draft, counts per inch, etc., a loomer or twister-in is required, who, with an adroit twirl, pieces each end on the new beam to a corresponding one which has been left in the heald from an old beam.

These men are remunerated for plain work at so much per 1000 ends, the drawer having more for the same number of ends. The order in which the ends are drawn through the healds is most important, although for plain and simple fancy work one system is generally adopted;

FIG. 19.

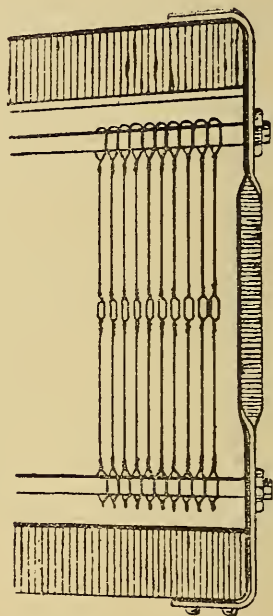

FIG. 18.

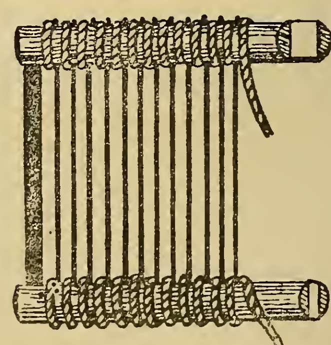

FIG. 20.

for fancier cloths the difference of draft is great, and regulates to a great extent the kind of figure produced on the cloth. These healds and reed are required in

the loom, being of great importance with regard to the proper interlacing and guidance of the ends. The healds, sometimes called heddles or gears, are of cotton or worsted, and are used in making the shed for the passage of the shuttle. The usual form is a loop, tied through which is a second loop, knotted so as to leave a quarter-inch eye. Fig. 18 explains the structure. The healds are knit in a special machine, and when finished show the loops ten inches deep, connected with a braid running along the top and bottom. The eyes are closely or sparsely arranged, according to the counts of reed for which the healds are intended. Staves are inserted in the top and bottom loops, and a set of healds consists of three or more staves. Plain could be woven by two staves, but four are almost always employed. The ends of warp are drawn through the healds, one through each eye. The method of separating the warp to form a shed is apparent. For example, suppose a warp of 2000 ends be drawn on four healds, each having 500 eyes, and two of these healds be raised whilst the other couple is depressed, a shed of two equal parts will be formed.

Metallic healds are being introduced, we believe, satisfactorily. The loops and eyes are of wire, sliding on bars attached to the staves (Fig. 19). A set of healds may be used for different counts of reeds.

The reed, comb or ravel (Fig. 20) is an arrangement of dents—pieces of flattened or polished wire four or five inches long fixed between strips of wood by pitched band. The dents are closer or not as the reed is finer or coarser in counts. Generally, two ends are drawn through each split or dent.

CHAPTER IV.

WEAVING, PLAIN LOOMS, SHEDDING, PICKING, BEATING-UP, OTHER MOTIONS, MODIFICATIONS OF LOOM, SPLIT MOTIONS.

THE last process of manufacturing, and the one in which all the preceding ones culminate, is weaving. This has for its object the combination of the warp and weft yarns, interlacing one with the other in such manner as to produce a firm texture, fitted for the varying uses to which cotton cloth is adapted—for warmth, for ornament, for trade purposes—for sale. The power looms of the present day, as employed in the cotton industry, vary very little in construction in the most widely separated districts, unless for very different classes of work, then what modifications are required consist of extra mechanism added to our common type—the plain loom.

THE PLAIN LOOM.

The machine required for the weaving of plain cloth, or cloth in which each end of weft and twist is interwoven alternately and on the face of which no figure is shown, is simple. The warp yarn is contained on a beam, the weft is placed in a shuttle, and the loom consists of the necessary framework and mechanism for holding the warp in the required position, passing the weft between alternate warp threads.

A general view of the loom is shown in Fig. 21, whilst a detailed representation is given in Fig. 22.

In the process of weaving it is necessary to hold the warp somewhat tightly, each portion at the same tension, and to obtain this condition the cloth is pulled forward by the taking-up roller as it is woven; but the warp is held back by the friction of weighted chains or ropes on the collars of the beam. The warp passes upwards from the

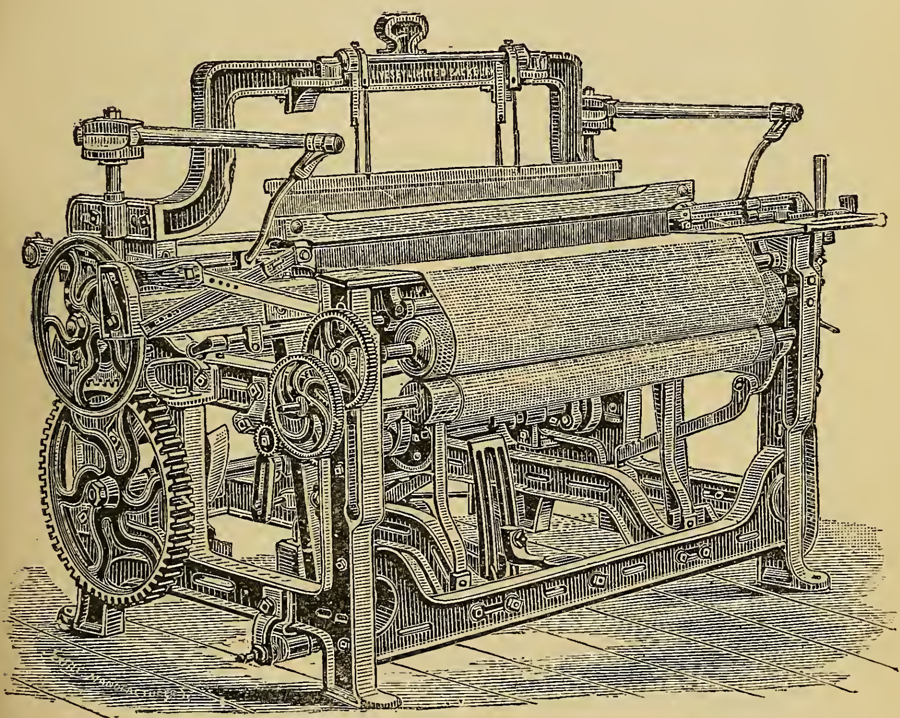

FIG. 21.—PLAIN LOOM.

(Front View.)

beam, over the back rest, and thence to the back of the healds; between the back rest and healds are the lease rods—a large one with a smaller rod nearer the healds. By means of these rods the warp is separated into equal portions, two ends passing alternately over or under the thick rod; those passing over the thick one also run under the thin rod. The rule commonly observed for four healds is to have the ends passing the first and the third heald

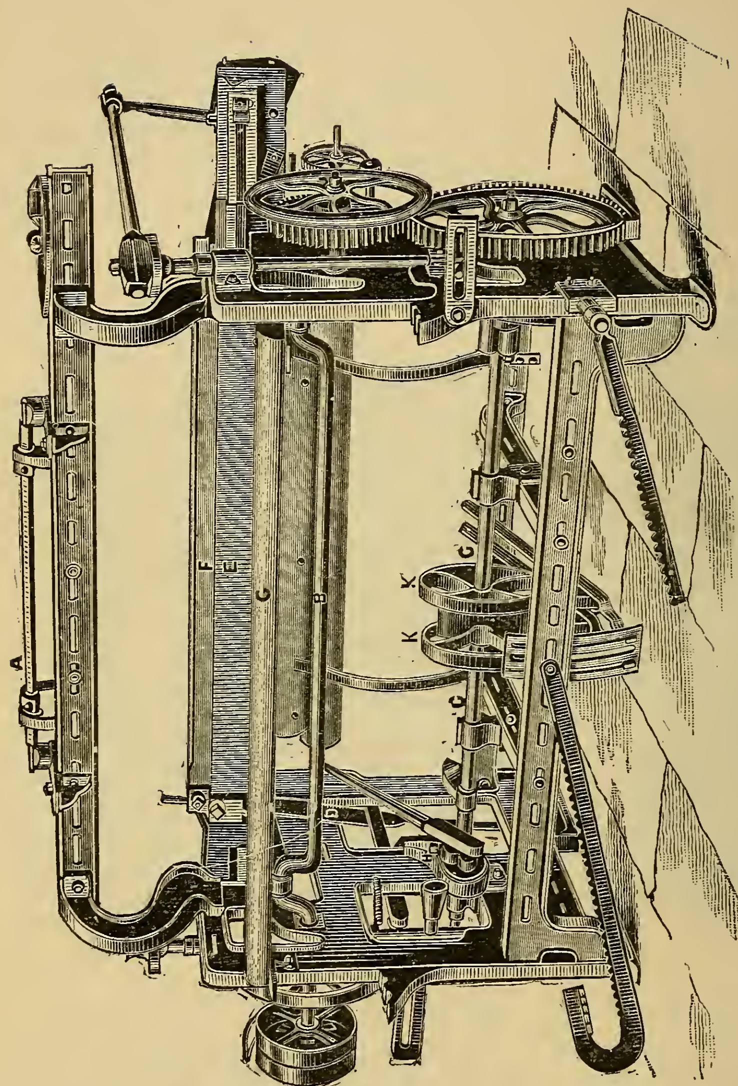

FIG. 22.—PLAIN LOOM.
(Back View.)

over the thin rod, and those drawn through the second and fourth over the thick rod, and consequently under the thin one. The first heald is the one nearest the front of the loom; the draft is 1, 3, 2, 4, and applies to plain cloth, although the first and second healds are worked as one, and the third and fourth together. Respecting the two ends which pass together at the lease rods, the one through the front heald is to the left of the one through the third heald; whilst with the other couples, the end through the more forward heald is to the left of the other. The weaver, bearing these rules in mind, can thus find the place of any broken end. The healds are suspended on each side of the heald roller A by means of straps and cords, which are shown. The portion of the heald roller supporting the back healds is larger than for the front ones; this is to make the former when lifted make the shed at the same angle as the front healds. Below are seen the crank shaft B, and the tappet shaft C, driven from it at exactly half the speed. The latter shaft bears the picking plates H and shedding tappets K. The slay, supported by the slay-sword* D on the rocking shaft is shown also. It carries the reed at E, held in position by the slay-cap F. The back rest at G, over which the warp passes, and the weight levers and driving pulleys are also noticeable parts. The cloth is woven pick by pick, and the whole action of the loom may be comprised in repetitions of the operations contingent on putting in one pick. Supposing the warp to be in position and the whole machine in weaving order, the first movement is to open the warp into two parts, and is called shedding; the second is to pass the shuttle through the opening thus made, called picking; and thirdly, to beat up the weft close to the pick last put in—technically, to the fell of the cloth. In addition to these, auxiliary movements are taking place for winding on the woven cloth, keeping it distended, and checking the motion of the loom in case of accident.

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* In addition to the references given in the text, each article is shown on Plate V.

SUNDRY FITTINGS FOR LOOM.—FIG. 21.

The illustrations on the opposite page represent a number of the various cast-iron parts which form a loom.

---

1 Back Bearer
2 Swing Rail
3 Brake
4 Brake, with Loose Clip
5 Stop for Bobber Wire
6 Gib for Crank Arm
7 Cotter for Crank Arm
8 Short Strap for Crank Arm
9 Step for Pin for Slaysword
10 Block for Crank Arm
11 Brass Steps for Crank Arm
12 Long Strap for Crank Arm
13 Bracket for 2-rod Vibrator
14 Eccentric for Vibrator
15 Crank Wheel
16 Swing Rail Brackets
17 Counter Twill Wheel
18 Large Twill Wheel
19 Small Twill Wheel
20 2 by 1 Leaf Tappet
21 2 by 2 Leaf Tappet
22 Large Tappet
23 Plain Tappet for Twills
24 Twill Bowl
25 Large Heald Boss
26 Small Heald Boss
27 Radius Bracket
28 Tappet Wheel
29 Slay Sword for Loose Reed
30 Slay Sword for Loose Reed
32 Slay Sword for Fast Reed
33 Pulley
34 Strap Fork Bracket
35 Strap Fork Bracket
36 Brake Stud and Bracket
37 Taking-up Catch Bracket
38 Brake Lever
39 Frog Plate
40 Frog for Opposite Side
41 Strap Fork Bracket
42 Bush for Old-make of Looms
43 Binder Boss for Twill Shaft
44 Dollhead Bracket for Twills
45 2 by 2 Leaf Dollhead
46 Small Tappet
47 Plain Treadle Bracket
48 Plain Treadle Grate
49 Dollhead for 2 by 1 Twills
50 Plain Dollhead
51 Change Wheel
52 Rack Wheel
53 Strap Fork Bracket
54 Frog (spring handle side)
55 Picking Bowl Stud
56 Loom Side Cap
57 Yarn Beam Bracket
58 Picking Bowl
59 Picking Bowl Collar
60 Picking Boss
61 Top Plate for Picking Stick
62 Under Plate for Picking Stick
63 Square Hole Cap
64 Picking Plate
65 Picking Neb
66 Hat for Picking Shaft
67 Foot-step for Picking Shaft
68 Swan Neck
69 6in. Ruffle
70 Fly Wheel
71 4in. Ruffle
72 Spring Bracket for Picking Shaft
75 Incline
76 Weft-fork Holder
77 Weft-fork
78 Brake Lever Rest
79 Bowspring Bracket
80 Bowspring
81 Upright Temple Spring
82 Under Spring
83 Small Spring
84 Knocking-off Finger
85 Hinge Spring
86 Front Plate for Slay
87 Bracket or Rest for Stop Rod
88 Finger for Loose Reed Stop Rod
89 Stop Rod, Rest, and Bracket
90 Heater Spring
91 Heater
92 Brake Wheel
93 Flange
94 Beam Wheel
95 Carrier Wheel
96 Cloth-rod Finger
97 Taking-up Lever Catch
98 Taking-up Lever
99 Three Leaf Treadle Grate
100 Twill Treadle Bowl
101 Twill Treadle Bracket
102 Long Twill Treadle Bracket
103 Treadle Bowl
104 Treadle Bowl Pin
105 Four Leaf Treadle Bracket
106 Four Leaf Treadle Grate
107 Holding Catch Bracket
108 Holding Catch
109 Carrier Wheel Stud
110 Carrier Wheel Stud Bracket
111 Treadle for Small Tappet
112 Twill Treadle
113 Change Wheel Boss
114 Taking-up Catch Lever Bracket
115 Back Lever Stud for Reverse Way
116 Binder
117 Duckbill
118 Slay Stud
119 Regulating Finger
120 Slay-stud Bolt
121 Hook for Chain on Cross-rail
122 Boxwood Strap Guard
123 Fly Spindle
124 Shuttle Guide
125 Slay Plate
126 Spring Hook
127 Swell
128 Incline Tumbler
129 Organ Handle Bowl
130 Organ Handle
131 Box End
132 Box End Spring
134 Tricker
135 Loose Reed Weft Grate
136 Loose Reed Weft Grate Neb
137 Fast Reed Weft Grate Neb
138 Fast Reed Weft Grate
139 Bow Spring Bracket
140 Weight Lever Spring
141 Under Beam Lever
142 Under Beam Lever Bracket
143 Weft Lever Bracket
144 Hammer
145 Temple Spring
146 Greyhound Tail
147 Hammer Stud
148 Hammer-stud Bracket
149 Tumbler Bracket
150 Tumbler Neb
151 Weight Lever Hook (reverseway)
152 Weight Lever (reverseway)
153 Usual Weight Lever
154 Plain Treadle for Large Tappet
155 Vibrator Lever
163 Loose Clip for Brake
164 Back Bearer Bracket
165 Crank Shaft Bush
166 Brake Weight
167 Fast Reed Brake
163 Weft Lever Stud

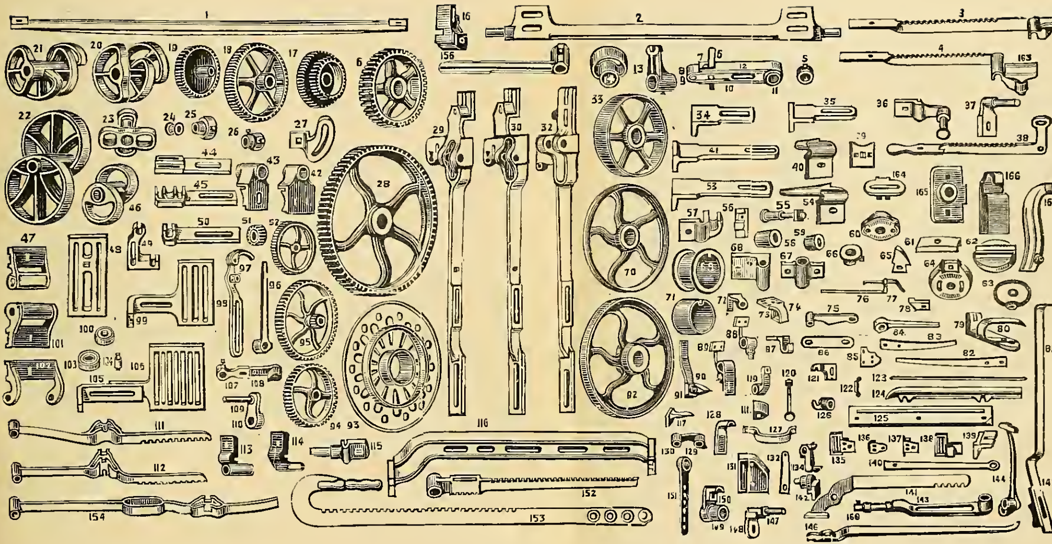

PLATE V.—PARTS OF PLAIN LOOM.

To face p. 56.

SHEDDING.

Shedding is very important, and more so in figured cloth than in plain; for it is by the shedding in its varied character that fancy cloth is principally produced. For plain cloth, a two-leaved or two-plated tappet is fixed on the tappet shaft, acting on a bowl fixed to the end of a lever, as shown in sketches of looms. There is one lever or treadle to each plate, and the heald worked by it is attached at the centre by wire, and a small corded cross-piece of wood, called a lamb. From the sketch it will be seen that, as the tappets revolve, the healds are alternately lifted and depressed, opening the shed in the warp. The shed for one pick will have the front heald at the top, and the back one at the bottom; whilst for the next pick their positions are reversed. The tappets are of rather peculiar form, a common shape for plain being shown at Fig. 28.

Working on the centre S the eccentricity obtained is employed in depressing the healds, but by an intermittent movement. The shed must be opened quickly to economise time, but must be left open sufficiently long to enable the shuttle being picked through. A reference to the shape of the plate in Fig. 28 will show this. From N to H is the portion for depressing the heald, from G to H being an arc of a circle and the part by which the heald is held stationary, while G M corresponds inversely with F N, and allows the heald to rise. It is necessary for the eccentricity to be equal at each shed, a point which may be tested by noticing if the sway of the beam is the same at each shedding. To get this, the treadles must be level when the healds are, and the centre of the bowl directly under the centre of the shaft. The bowl should be in contact with the tappet during the whole revolution, and thus give an easy tread—jerky motion in either treading or picking being very detrimental to good weaving. A good shed should be almost as large as the shuttle at the point where it passes through, quite clear from obstructions of any kind, and the lower half of it not too low, or,

as it is termed, not "bottoming" too much, for when too low the warp is frayed by the movement of the slay.

A point regarding which weaving technologists often enter into profuse arguments and diagrammatic illustration, may here be summed up in a few words. The line of warp when the healds are level should be below a line drawn from the temple to the back rest, and the lower the healds are in this respect the better is the cover on the cloth, although attention must be given to the remarks in a previous paragraph regarding bottoming. Whether the lowness of the warp line is produced by depressing the healds or raising the back rest is immaterial.

When plain cloth is woven in a twill loom, the tappets act above the centre of the treadle, and of course are of smaller size, the healds being connected to the end of the lever opposite to the fulcrum.

The calculation of the size of the shed from given dimensions of the tappets and treadles forms a good example in leverage. Suppose the stroke of the tappet, or the distance through which it moves the treadle bowl (represented in Fig. 28), between the outer and inner circles is $3\frac{1}{2}$ inches. The treadle is 30 inches long, the treadle bowl being 25 inches from the treadle pin, and the healds connected 15 inches from the pin or fulcrum at N. Then the movement of the heald from its highest to its lowest level is equal to the distance moved through by the point N—*i.e.*, 2·1 inches—for if the bowl moves $3\frac{1}{2}$ inches, the point N moves $\frac{3\frac{1}{2} \times 15}{25} = 2{\cdot}1$ inches. This gives the size of the shed at the healds. Suppose the heald in question is 7 inches from the fell of the cloth, the shuttle passing through the shed 2 inches nearer to the cloth, then the size of the shed at the heald multiplied by 5 and divided by 7 gives its size at the point where the shuttle passes through, or $2{\cdot}1 \times 5 \div 7 = 1{\cdot}5$ inches.

There is a slightly different shedding arrangement adopted in some looms, frequently so in Yorkshire, but rarely in Lancashire. This is the Bradford gear shown in Fig. 23. The tappets are placed outside of the loom, and the treadles are connected to the healds through

jacks at the top of the loom. A leaf or projection on the tappet in this arrangement causes the heald to rise, not depressing it, as in the previously described arrangement.

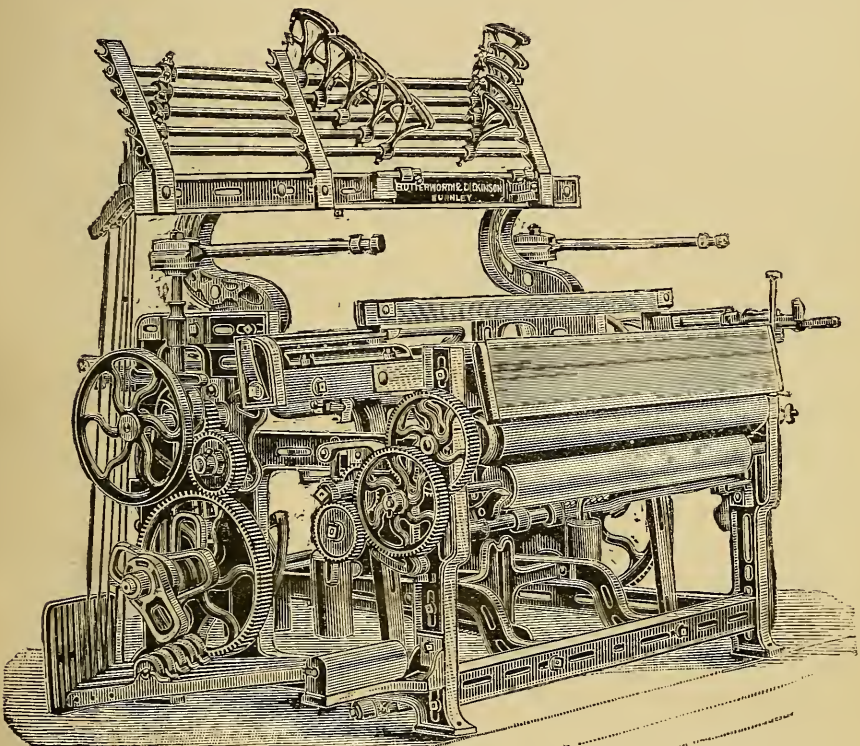

FIG. 23.—BRADFORD LOOM.

PICKING.

Among cotton looms the over-pick or Blackburn pick is commonest. Attached to the tappet shaft are picking plates, one at each side of the loom. As the picking arrangement at one side is similar to that at the other, a single description applies to both.

The picking plate ends in a point and acts on an upright picking shaft through a stud affixed to the latter. The point is removable and is lengthened in broader looms about $\frac{1}{8}$ inch for every 10 inches wider reed space. At the top of the picking shaft is a picking stick, an arm of some

30 inches long, carrying a band connected with the shuttle box of the slay. It is now necessary to describe the slay. This is a beam of wood along which the shuttle is passed through the shed and by which the reed is held to beat up the weft. Its length is about 3 feet more than the width of the cloth being woven, the space at each end being taken up by the shuttle boxes. These are cavities open at the top and at one end just sufficiently wide to hold one shuttle. Parallel to the bottom of the box or fly-plate is a spindle carrying a hard piece of horny substance called a picker. To the top of this the band from the picking-stick is attached, whilst at the bottom the shuttle rests against it. The back of the box forms an angle of 86° with the fly-plate—thus, as it were, forming a dovetail into which the shuttle is bevelled to fit. The space between the boxes is called the shuttle race ; it is not absolutely level, the middle point being from $\frac{1}{8}$ to $\frac{1}{4}$ inch lower than the boxes, the greater depression being for wide looms.

It will be easily seen how the revolution of the picking plate actuates quickly the picking shaft, and consequently the end of the stick, with an increased speed. The blow is transmitted to the picker and the shuttle driven across the slay into a similar box at the other side.

When a new shed has been formed by the healds it is driven back again.

A smooth pick is most desirable, and for this reason the stud on the picking shaft must be set so as to receive a smooth *side* blow from the plate, neither a downward nor an upward one. This is a point in the tackling of looms which receives the attention of every good overlooker.

The shuttle used in the ordinary classes of cotton goods is of box or some other heavy wood pointed and tipped at each end with iron. The usual length is about 13 inches and depth $1\frac{3}{8}$ inch. Care must be taken that it is smooth at all parts where it comes in contact with the twist, free from knots or other flaws, which, should they give, would make havoc among the threads.

The weft is in cop form, and fits on a peg inside the shuttle, the loose end from the cop nose being drawn

through the shuttle eye by a strong inhalation of air by the weaver. To prevent excessive waste the manufacturer should obtain yarn well copped, the cops hard, free from nicked places caused by the minder having his ends down; clear apertures at the bottom of the cop, which should also be free from backlashing—that is, ends hanging slackly below and over-lapping those previously wound on. Weft cops, or pin cops, should be five inches in length, and as thick as the shuttle will admit of. Weft yarn is selected according to its evenness, good cover or nap, and cleanliness.

Beating Up.

The shot or pick of weft often being put through the shed, is at a distance of five inches from the woven cloth, and requires pushing up into close contact with it. The motion of the slay performs this operation. As explained on page 60, the slay is a beam of wood carrying a reed, and having a reciprocating motion to and from the fell of the cloth, imparted to it by the cranks on the shaft (Figs. 22 and 43.) The beam is supported on two vertical rods, called slay swords, attached near the bottom of the loom to a vibrating or "rocking" shaft. The slay is away from the cloth or front centre a sufficient time to give opportunity for the propulsion of the shuttle through the shed. Were the crank-shaft at the same level as the slay-sword pin, the dwell at each end of the stroke would be exactly equal—a dwell of some duration, however slight, it is obvious, there must be. However, the centre of the crank-shaft is at a lower level than that of the connection of the crank-arm with the slay-sword ears, and thus the slay dwells longer at the healds than at the cloth. As the slay makes some 200 strokes per minute, the variations of speed at the back and front centres are scarcely observable, but by means of exact measurements a certain amount of dwell may be traced at the back centre.

By describing a circle to represent the movement of the crank, and at a distance from it drawing to scale an

arc of a circle to represent the movement of the slay, we can prove the foregoing remarks. In Fig. 24 the circle referred to is shown, and also the line A E representing the stroke of the slay. By observing the position of the ends of the connecting rod E^1, when in contact with the circle at the back centre, and also when the slay is at front

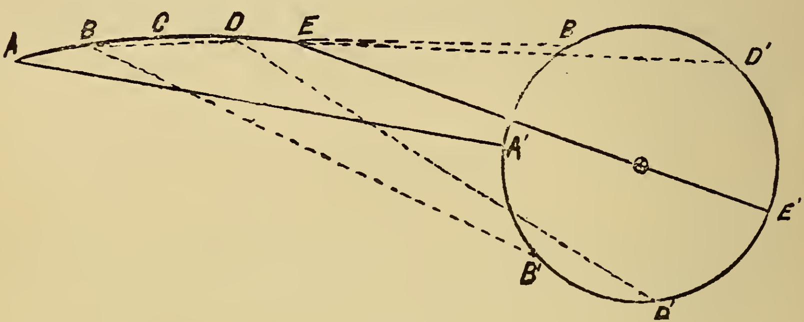

FIG. 24.

centre, we find that it has travelled over from E^1 to A^1, which is more than half of the circle. Then assuming that the crank-shaft runs at one even speed, we would say that the slay takes longer time going forward than coming back. Again, by measuring the movement of the slay from A to B at the front, and from D to E at the back, these parts are found of equal length, but by extending from these points our crank-arm of equal length in every case, we find that to move the slay from B to A and back occupies a space on the circle from B to B^1, while to move the slay from D to E and back occupies a space from D^1 to D^1 obviously greater, from which fact we assume that the slay occupies a longer time at the back than at the front, an arrangement purposely contrived so as to get theoretically a longer dwell. The difference between the arcs D^1 D^1 and B B^1 is approximately 15°. Calculating at 180 picks per minute, we get the difference between the time of dwell at front and back to a seventy-secondth part of a second—to a practical mind not a very great consideration.

The shuttle race is made of hard wood laid on the beam, and in addition to the depression at the centre is also rather wider at the middle of the race—at that point bulging out slightly against the reed, which is kept in contact with it by the slay cap at the top and the reed case at the bottom. Care must be taken to keep the ends of the reed from projecting in front of backboard, or the shuttle will be thrown out.

Loose and Fast Reeds.

To obtain a firm blow at the cloth the reed is made to strike it at right angles, for if the angle were more obtuse or acute a loss of force would be entailed by a consequent downward or upward stroke imparted to the cloth, the line of action not being in the same plane as the line of reaction.

With regard to the firmness of the beating up, we have to consider the merits of fast and loose reed looms.

In weaving, an accident which not infrequently occurs is the stoppage of the shuttle when it has only traversed a portion of the distance across the warp. A case of this shuttle trapping causes the breakage of more or fewer ends, and consequently arrangements are made for preventing much damage, either by arresting the motion of the loom suddenly, in case of a fast reed, or by having a reed hanging loosely behind the shuttle so as to give way in case of a "mash." The latter arrangement is preferable, as there is not the sudden concussion given to the loom, which causes the vibration and straining of every part, so objectionable in the fast reed loom; the loose reed can, however, only be used for light and medium cloths, as the reed is too lightly fixed to give a strong beat-up. In the case of the loose reed, the slay cap holds the upper part of the reed in a slot, the bottom part being pressed against the shuttle race by a strip of wood (completing the reed case) attached to the stop rod. When at the fell of the cloth, the stop rod is held firmly by a spring, and a fairly strong blow can be given to the

cloth; but at all other portions of the slay's movement nothing holds the reed but a weak spring acting on the casing, and if the shuttle traps, the reed flies out, while a finger on the stop rod knocks the loom handle off, stopping the machine without unnecessary concussion. This latter advantage enables the loose reed loom to be run at a speed of some 30 or 40 revolutions more than the fast reed.

Fast Reed Loom.—Here the loom is stopped suddenly in case of the shuttle being stopped in the shed.

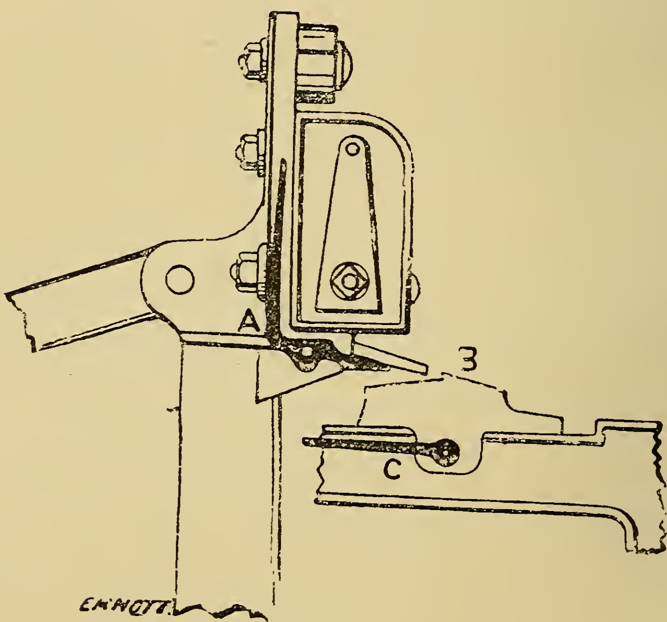

FIG. 25.

From Fig. 25 the arrangement will be understood. A swell attached to the shuttle box is placed so as to project into it when the box is empty, and through an L-lever A drops a catch so as to strike the frog B and arrest the motion of the slay. The frog moves a short distance and puts the loom brake in action before checking the motion

of the slay. This is done by means of the rod C. The catch is attached to the slay sword and rests on the lever A. When the shuttle is in the box, and as the slay is on the top centre, the protector rides above the frog about a quarter of an inch; it is only when the shuttle has not landed in its place that the loom is stopped. There is an arrangement for the swell to be released at the time picking takes place, so as not to give unnecessary obstruction to the shuttle.

Take-up Motion.

Among cotton looms the positive take-up motion is generally used. The cloth as woven is, by this arrangement, drawn on the cloth roller a certain distance at every

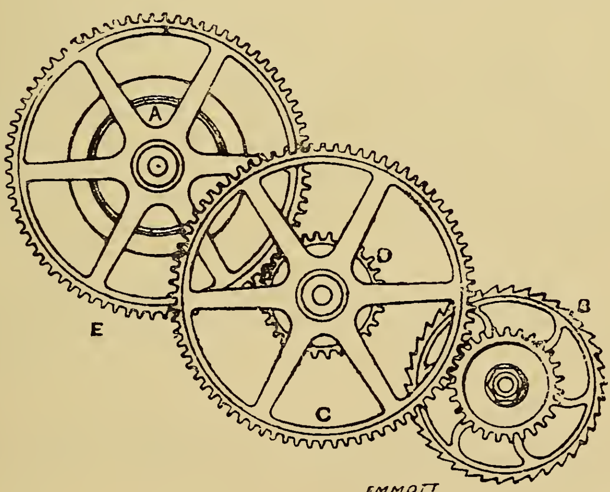

FIG. 26.

pick, the amount of take-up being regulated by wheels. Fig. 26 shows a sketch of the arrangement. The construction is similar for almost all looms, but there are

different gears and sizes of wheels used. In Dickinson's gear the rack wheel of 50 teeth receives its motion from a pawl, worked by one of the slay swords. On the same stud is the change wheel: this gears with the stud wheel, 100 teeth, firmly connected with the pinion of 12 teeth, driving the beam wheel 75. The beam or sand roller is 15 inches in circumference, and is covered with glued sand, perforated tin, or some pointed substance, to hold the cloth firmly. The fabric is wound on the cloth roller below this by means of contact with the sand roller. The change wheel is varied to give changes of picks in the cloth, a larger wheel giving fewer picks in the quarter inch. Each gear has a constant number associated with it, called a dividend. If the number of teeth in the change wheel be divided into this dividend, it gives the picks in a quarter inch of cloth. Imagining that a change wheel, having the effect of only one tooth in a revolution, could be applied, then the dividend is the number of picks that the loom would run before the sand roller advanced a quarter of an inch. Suppose 528 dividend is taken, this represents a change wheel supposed to have one tooth. If a wheel of 66 teeth be put on, only $\frac{1}{66}$ as many picks to the quarter will be inserted—*i.e.*, $\frac{528}{66}$ = 8 picks.

The method of obtaining the dividend for any ordinary gear is—

$$\frac{\text{Rack wheel} \times \text{Carrier wheel} \times \text{Beam wheel}}{\text{Pinion wheel} \times \text{number of } \frac{1}{4} \text{ inches in circumference of taking-up roller}}$$

afterwards adding $1\frac{1}{2}$ per cent. for shrinkage of the cloth after being released from the tension of the loom.

Thus, Dickinson's gear is—

$$\frac{50 \times 75 \times 100}{12 \times 60} = 520.$$

$$\text{Add } 1\tfrac{1}{2} \text{ per cent.} = 7.8$$

$$\text{Dividend} \ldots \ldots 527.8$$

The principal gears in use in Lancashire are:—

	Rack Wheel.	Stud and Carrier Wheel.	Pinion.	Beam Wheel.	Circumf. Take-up Roller.	Dividend.
J. Harrison & Sons, now J. Dugdale & Sons	50	100	12	75	15	528
H. Livesey & Co.; Willan & Mills; J. Dugdale & Sons; J. & R. Shorrock	50	120	15	75	15	507
Butterworth & Dickinson	50	100	12	75	15	528
W. Dickinson & Sons	50	120	15	75	15	507
Geo. Keighley	50	140	15	78	14½	637
Pickles	24	89	15	90	15	—

Pickles' gear also has a swing pinion 24, and 2 change wheels; to find the change wheel required, multiply the change wheel on the rack stud by the picks per quarter inch, and divide by 9—

Equal to 4 teeth per pick for a 36 change wheel.
,, 3 ,, ,, ,, 27 ,, ,,
,, 2 ,, ,, ,, 18 ,, ,,

By using this motion, which is shown on Fig. 23, both heavy and light pick cloth can be woven without a great variation in the wheels.

To weave heavy pick cloth with, say, the first-named motion, the rack wheel might be increased to 60 from 50, and the dividend would then be 634.

In some looms a letting-off motion works in conjunction with the take-up, to release the yarn on the beam at a fixed rate.

The Weft Stop Motion.

A reference to the invention of this very ingenious and useful apparatus is made in Chapter I. Its object is to stop the loom on the breakage of the weft, or when the cop is finished. Unsightly gaws or goals in the fabric are thus prevented, and the weaver enabled to attend to more looms. A lever is fixed to the breast beam (Fig. 27), hinged at one end, and arranged so as to rest against the starting handle E. The lever carries a bent fork C, which

projects into a grid D in the slay at the moment that the crank is at the fore centre. The grid is let into the back board of the slay between the reed and the shuttle box at

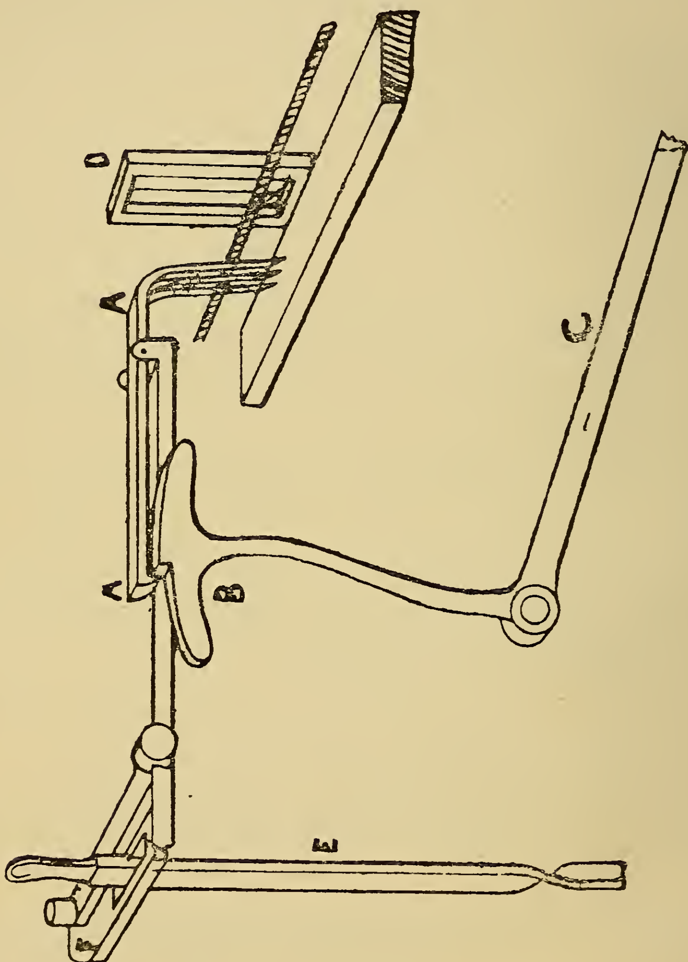

FIG. 27.

the starting side of the loom. On the tappet shaft is fixed a projecting cam or sector, raising one end of a bent lever C, the lower part of which is called the greyhound tail, and the upper part, which ends above the breast-plate, from its peculiar form is dubbed the hammer. The fork before referred to is balanced, and its back end hooked and resting on the hammer.

When there is weft in the loom the fork is prevented by the thread from passing through the grid, and its back part is thus lifted clear of the hammer. Should the weft be broken, the loom is stopped thus: The sector raises the greyhound tail at the moment that the slay is at the fore centre, and there being no weft to raise the fork, it is caught by the hammer, and the lever to which the fork is attached pulled forward, when, as previously referred to, the spring handle is released and the loom stops. Manifestly the motion must be set so as to act when the shuttle is at the fork side of the loom.

The Brake.

A good brake contributes greatly to the manufacture of even cloth ; should the stopping arrangements be ineffective, thin places and cracks will be inconveniently numerous. Usually the brake is a simple lever acting on a brake pulley at one end, whilst at the other it is regulated by an inclined bracket connected with the starting handle. When the handle is pushed forward, the brake lever is lifted ; when the knocking-off takes place the end of the brake lever drops and the leathers come in contact with the pulley, stopping the loom. Additional brake power may be made by altering the leathers or weighting the brake lever.

Temple Rollers.

The cloth as it is woven tends to contract in width in consequence of the tension at which it is wrought lengthway, and to counteract this, temple rollers are used. For commoner heavy fabrics the roller and trough is used, and consists of a fluted roller cut in the manner of a screw at either end, one end with left-hand thread and the opposite end a right-hand. Thus a spiral row of points is left at each end of the roller, and it is fixed in the loom, so that as the roller revolves the points distend the cloth. The roller is fixed in a trough for convenience in attaching to framework. Lighter fabrics are woven with

side temples. These are small rollers acting only for a distance of 3 to 4 inches at the selvages of the cloth. Two pairs are usually used at each side, the contrary-thread spiral arrangement being preserved; a bar of iron connects the two sides. In the latter arrangement the weaver can see the cloth from the moment it is woven, which is not possible with the roller and trough, as some two inches are hidden under the roller: the cloth is not held so firmly at the middle of its width.

Timing.

All the contrivances just described are required to work harmoniously in order to produce the desired results, each coming into action at the proper time. In plain cloth weaving, when the crank is at the fore centre, the reed touches the cloth at right angles, and the healds are slightly open, forming a new shed. As the slay moves backwards just in front of the bottom centre, the picking band is tight and just commencing to move the shuttle. At this point the healds are full open and remain so until the crank has passed the back centre, when, as the shuttle has arrived in the opposite box, the shed begins to close. Before the slay has reached the front again, indeed when just past the top centre, the healds are level; an advantage is thus gained in having the rods crossed on the weft at the time it is beaten up, holding it firmly. The sector lifts the greyhound tail for the weft stop motion at the moment that the reed touches the cloth, when the fork would be lifted if there were weft in the loom. This only happens, of course, every alternate pick, when the shuttle is at the fork side of the slay. Generally the monkey tail on the slay sword moves the take-up pawl as the slay moves back, just dropping the holding catch as the crank reaches the back centre.

The reed is held tightly in a loose reed loom when the slay approaches the front. Of course, the timing of the motion varies under different circumstances; if cloth is being woven as wide as the loom will possibly admit of, or if the shuttle boxes be short, then picking necessarily

must take place later, as the shuttle starts so close to the cloth; consequently, shedding must be later or the shed will close before the shuttle is through. Of course in this case the pick must be stronger, as the shuttle has more friction in its traverse. Other circumstances also affect the timing.

The Position and Fixing of the Looms.

In a weaving shed the looms are driven from shafting running parallel to the looms when looked at lengthway. Drums on the line shafts drive the loom pulleys by means of straps. Of these pulleys there are two, generally about 9 inches diameter for a 40-inch loom. One pulley is loose on the shaft, the other keyed to it—the former to carry the strap when the loom is stopped. The looms are in groups of four, with an occasional row of couples for two or three loom weavers. The four arrangement is adopted for convenience to the weaver, as the looms having the starting ends contiguous, he has little walking for the purpose of setting on the machines. Thus, two "hands" of loom are required, those with the starting handle at the right-hand side being named right-hand looms, and *vice versâ*. There is little difference in construction—the crank-shaft is longer in one than the other for the purpose of having two straps on one driving drum. Many parts, such as crank-shafts, slays, shuttles, forks, brackets, etc., are required to be of two "hands," each for its own hand of loom.

In view of a case of having to remove looms or fix new ones, a few remarks on the general arrangements for fixing them may not be unacceptable. The line shaft runs over the space between the warp beams of the looms. A line must be marked on the floor with chisel or other convenient instrument parallel to this shaft and exactly below it. By dropping a plumbline from various parts of the shaft, the starting points can be obtained for stretching a line to mark from. The same arrangement is adopted at every third shaft, as the intermediate ones may be measured. From these lines the distance at which the

loom feet are to stand may be measured, just leaving convenient space for getting between two full beams in each loom.

The ends of the loom must be set parallel also, so that on looking down the shop a straight row of machinery will be observed. A line for setting the outside loom feet may be measured from the pillars, after getting the first pair of looms in suitable position. To test the accuracy of these measurements, the breast beam of each loom, as fixed, must be examined in a line with the breast beam of the previously deposited one. After the correct position is obtained, each loom must be levelled up by thin sheets of wood packing placed under the feet as required. Holes are then drilled in the floor, wood pegs inserted, and long iron nails driven home.

A good passage round each group of four looms cannot be too greatly valued, and likewise a broad alley here and there running the whole length of the shed.

Loom Tackling.

A loom requires a considerable amount of repairs and renewals, the performance of which is delegated to an overlooker (sometimes called a tackler or tuner) placed over each hundred looms. If on fancy goods, fewer looms are under the control of one man; if plain narrow goods are woven, more. His work is to keep the looms supplied with warps, gait them up, repair or tackle the loom when necessary, provide weavers, and, especially in a small place, perform rather multifarious duties. When the weavers' beam has been placed in the loom, having the healds and reeds attached to the warp, the overlooker draws the gears forward, placing a weight rope or chain round one beam ruffle, and, if a loomed beam, fixes the reed. The healds are slung loosely to the heald roller straps, and then the twist attached to the sand roller. If old healds are used, the lap end of a former cut is placed on the roller, and the warp tightened. If new healds have had the warp *drawn in*, a lap end is attached to the roller and the twist tied to it, care being taken to draw up any ends which may be ruffled. The temple is fixed so as to

revolve in the direction required to distend the cloth. Then with the cranks near the top centre, the healds are levelled by means of the cords below being attached to the lambs and treadles. After a little manœuvring so as to make the shed *bottom* nicely, whichever heald is down, to get the healds level all across, and clear of any obstruction or drooping ends, the lease rods are put in. The second and back healds are raised when the back rod has to be put through the front, the third being up for the thin rod. A few picks of weft being put through by hand, a start is made after finishing the weighting of the beam and changing the pinion, if necessary. The weighting is somewhat important; for light cloths, fine yarns and light picks less weight is required than for the heavier classes of goods. More weight is required for full beams and under certain other conditions.

It is impossible to enumerate all the little points in the management of looms, which it is the overlooker's duty to perform; and only long practical experience can teach their proper performance. However, neglecting the derangements, which cause faults in the cloth, and which will be treated of in the next chapter, we will refer to some of the commoner mishaps. The shuttle flying out of the loom is caused generally by some obstruction in the shed, floats, projecting reed, top of shed too low or bottom too high, or by a crooked spindle or bad picker. Cops flying off the shuttle peg may be attributed to too large holes in the cop, or shuttle spring too weak or unpacked. When the loom does not knock off when the weft is done, the fork may be bent and thus lifted by grate, an end of weft may be hanging to the shuttle sufficiently long to catch in the cloth and lift the fork. But for the cause of this, and also of the loom knocking off when weft is not broken, the weft stop-motion must be carefully watched. The picking may sometimes be so strong as to throw the shuttle out of the loom, or so weak as to allow it to be trapped by the closing shed. By judicious setting of plate and bowls, any desired result may be obtained.

When by the shuttle binding too tightly in the box, etc., a fracture of the weft is made, it is said to be "cut."

The Weavers.

The average weaver runs four looms, but in many sheds provision is made for three, or even two-loom weavers, whilst qualifying themselves for the higher number. In some North-East Lancashire towns five and six-loom weavers are not infrequent on narrow strong goods. The weaver's duties require some little skill, and consist of piecing up the broken ends of warp and drawing them through the heald and reeds, filling the shuttles with weft and placing them in the loom as those in working become empty, oiling, doffing "cuts," putting in the coloured headings—an important part of dhooty weaving—oiling, and performing simple repairs.

The wages obtainable on ordinary goods, such as shirtings and printers, should not be less than 11s. per pair, to give satisfactory results, while 12s. 6d. per pair on dhooties and simplest fancy goods is good.

The waste in this process is important, four per cent. being allowable on common yarns, say 36's, this being reduced on finer and consequently better copped yarns (weft).

The foregoing remarks apply to the weaving of plain cloths only, and that by the most usual methods. In any process whatever, it may be that some variation will be found to exist, and, before concluding this part of the subject, the modifications of the one standard type of loom may be referred to.

In shedding, the tappets may sometimes be placed on a third shaft, driven from the tappet shaft, and termed a twill shaft, because by altering the tappets and the speed the loom may be made available for weaving twills. When the tappets are fixed to the twill shaft they are smaller than those fixed to the tappet shaft.

Setting Out Tappet.

The setting out of a tappet is an important problem. Two circles must be described round the same centre, the difference in the radii being the stroke of the tappet—thus,

say A B or C D in Fig. 28 is $3\frac{1}{2}$ inches, then that is the stroke of the tappet. This is also the radius of the smaller circle. The large circle must now be apportioned according to the number of picks to the round in plain cloth, say two. The circle is then divided into two parts by E F.

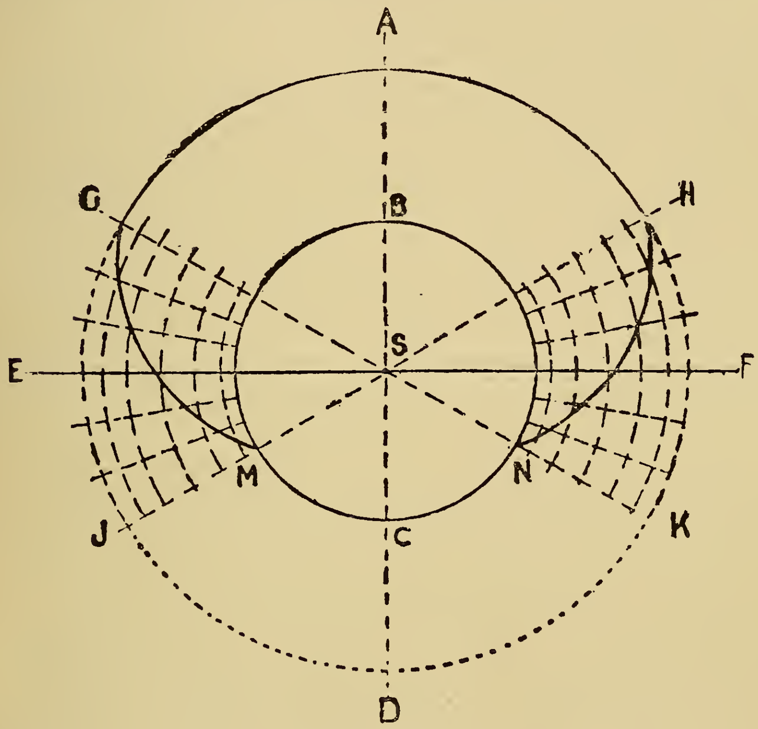

FIG. 28.

Suppose we wish the healds to be still during two-thirds of a revolution of the crank-shaft, then as E A F represents a whole revolution, divide it into six parts where marked, place four of these parts from G to H for the dwell, and leave E G to form part of the lifting, and F H part of the depression of the healds.

The movement of the rising healds commences, however, before the falling heald has come to a pause; therefore we must trespass into the lower half to an extent equal to E G and H F, thus obtaining by drawing a diameter through G and the centre, also through H and the centre,

the parts G J and H K for the rise and fall respectively. Divide C J now into six parts by radii to the centre, also divide by arcs of circles transversely, to these radii, the space between the small and large circles into six parts, then by drawing a line diagonally through the figures thus formed, we get a line G M giving an easy fall from the large circle to the small one, and by similar treatment a rise on the opposite side from N to H.

This is the theoretical construction of a plain tappet, from M to N being the dwell from the heald when up. N to H the depression, and H to G the dwell for the heald when down; and it will be noted, that although G H is apparently larger than N M, the time of dwell is the same in each case, in consequence of the arc N M being so much nearer the centre. In practice, the hollows N and M may be found rather fuller than shown here. This method of construction applies to tappets with an increased number of picks to the round, a point which will be found described in Chapter VI.

The speed of tappets is an important subject for calculation in connection with the loom. When the tappets are on the tappet shaft they are always plain, and are driven at half the speed of the crank-shaft, in consequence of the latter shaft only representing one pick, while the tappet shaft,* carrying two picking plates, represents two picks. Should the tappets be on the twill shaft, and driven from the tappet shaft, then the calculation is simple—*e.g.*, say four picks to the round are required, then the crank-shaft must revolve four times for the twill shaft once. The tappet shaft must revolve half as many times as the crank-shaft—that is, twice—and the ratio between the speeds is as 2 to 1, which is also the ratio of the wheels, say 16 and 32, or 20 and 40, the larger wheel being on the twill shaft. In this case the rule is to divide the number of picks to the round by 2, which will give the ratio of the wheels gearing the tappet and twill shafts.

* The term tappet shaft is used here in the sense understood in North Lancashire—*i.e.*, the shaft driven from the crank-shaft and carrying the picking plates and tappets if plain.

Occasionally, the shaft carrying the tappets is driven from the crank-shaft direct, and the ratio of the gearing will be as one is to the number of picks to the round—say 6 picks to the round—then such a pair as 12 and 72, or 15 and 90, will be required. Obviously, for a large number of picks, an intermediate pair would have to be inserted—say 13 picks to the round must be woven, the wheel on the crank-shaft being 25 and the last wheel on the same shaft as the tappets is 65. Then, to get the size of the pair of intermediate wheels on the stud, multiply 13 by 25 and divide by 65, which will give the ratio of the size of the two wheels:—

$$\frac{13 \times 25}{65} = \frac{325}{65} = \frac{65}{13}$$

These, or a multiple of these, are the wheels required, which may be proved:—

$$\frac{65 \times 65}{25 \times 13} = 13 \text{ picks to a round.}$$

Split Cloths and Motions.

Split cloths are sometimes woven in the ordinary loom when narrow widths are required and a perfect selvage is not a necessity. Thus, a 40-inch loom may weave a cloth with a few empty dents at the centre, whilst on each side of the space thus caused the warp threads are crossed (on the gauze principle) between each pick to make a firmer selvage than could be got by ordinary lifting. The weft threads are then slit along this space by a sharp knife, giving two cloths, each 20 inches wide. One system of forming the selvage is by having an extra loop attached to the top stave of one heald, and carrying a thread which is drawn through the other heald. By correct drafting this thread can be made to lift at every pick first on one side of its neighbouring warp thread and then on the other.

The same object is attained in a split motion, patented by J. & R. Shorrock, and Taylor, of Darwen. By means of eyeletted straps revolving round a tightened warp thread, the doup or crossing threads drawn through the eyelets make a very firm selvage when slit.

The picking motions require a few further remarks. For some goods, especially fancies, the under pick is used. In this case the picking stick is rather longer than the slay sword, and is fixed parallel to it, projecting from the rocking shaft through the shuttle box and picker. The loom, Plate VII., possesses the under-pick arrangement. It is driven by means of the picking plate acting *downwards* on a lever centred at one end, whilst carrying at the other end a strap fixed to the picking stick about four or five inches from the bottom end of it.

The scroll or side pick is a favourite one for velvet looms. The picking plates are fixed on the *crank*-shaft, and consist simply of a disc of metal carrying a lug so as to catch against a latch or lug on a short inclined shaft at the loom side. This shaft at the bottom end actuates by means of a strap and picking stick fixed as in the under-pick loom. Obviously, the picking from each side of the loom must be done alternately, and the plates at the loom side are arranged so as to act only once in two revolutions of the crank-shaft. This motion is obtained by means of a scroll plate on the crank-shaft carrying a groove forming an inner and outer ring in the plate; in this works a slide in the inner ring for one pick, then traversing the outer part of the groove for the second pick. This slide regulates the latch on the short shaft. When in the outer ring the latch is lowered so as to be caught by the lug on the picking plate, but is out of the way when the sliding piece is in the inner ring. Of course, when the slide is in the inner part of the groove at the right-hand side of the loom, the slide of the left-hand picking scroll is in the outer ring, so as to pick alternately. This picking arrangement is very compact.

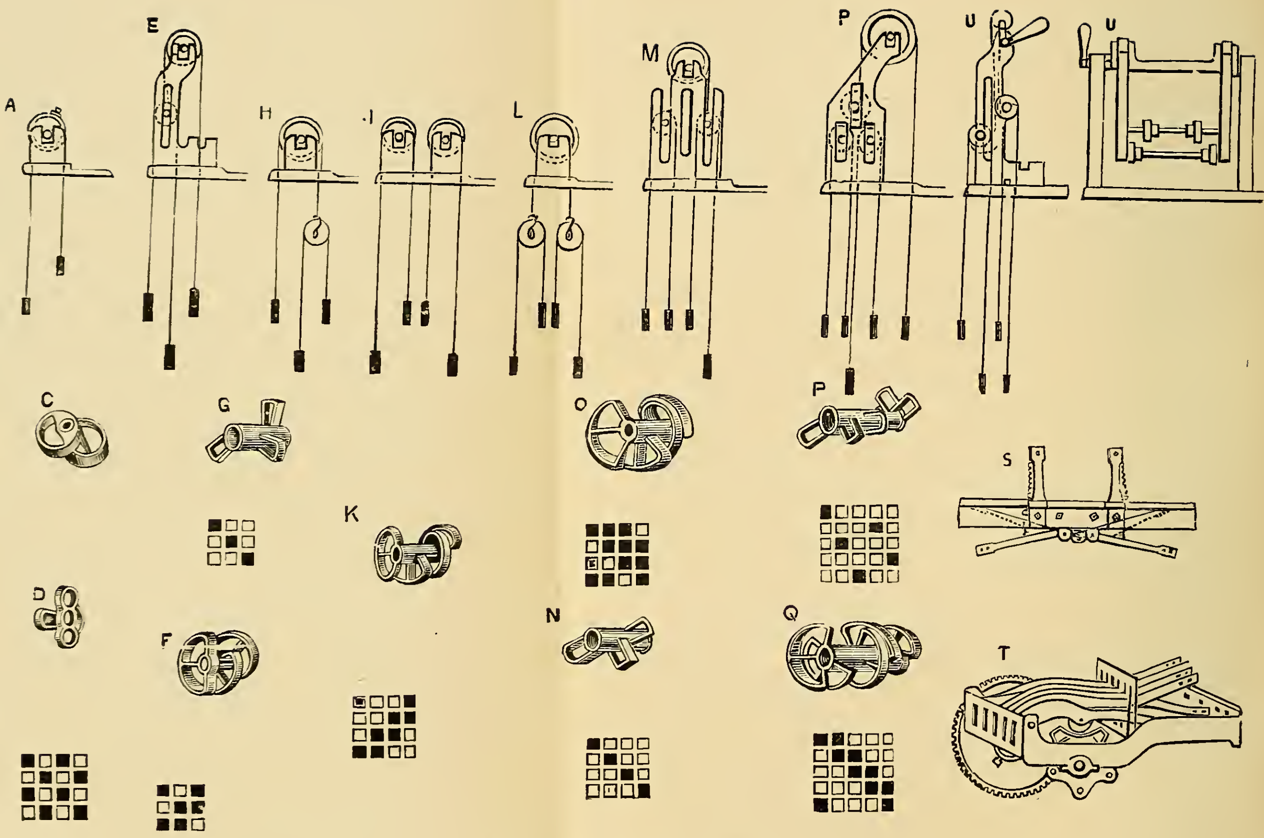

PLATE VI.—SHEDDING MOTIONS.

To face p. 79.

Speeds.—Average Speed of New Looms.

Reed Space.	Picks per Minute.			
	Plain.	If Dobbied.	If Drop Boxes.	If Double Cylinder Jacquard.
32 inches	240	190	190	190
44 ,,	200	175	175	175
54 ,,	180	160	160	160
66 ,,	150	150	150	150

On goods with ordinary headings, the stoppages for changing shuttles, piecing ends, etc., should not be more than one minute in twelve, or 8 per cent.

Reed Space.

The reed space of a loom is measured from back-board on the one side to the fork grate on the other. Thus, what is called a 40-inch loom measures 45 inches reed space, and in it it is usual to weave cloth up to 41 inches wide, although it is possible to weave $42\frac{1}{4}$-inch cloth in it. A 26-inch loom has a 30-inch reed space, and will weave to 28 inches. In wider looms the reed space is about six inches above the nominal size of the loom.

Top Motions.

In Plate VI. are shown a number of top motions to keep the healds tight when worked from below. Each is self-explanatory, and by imagining the effect of changing the heald or healds which are up for others, the value of each arrangement will be seen. For example—take H, a 3-shaft motion, two up. If No. 2 be required up and No. 3 down, the change is made without any movement of the top pulley; if No. 1 be required down and the other two up, it will be drawn down a distance equal to the size of the shed—say 2 inches; whilst the small pulley being connected to a step pulley on the larger one, is only lifted half that distance—say 1 inch. Now, if the small one be raised 1 inch and No. 3 heald be kept still, No. 2 heald will lift 2 inches—the height desired.

It will be noted that a top motion is adapted only for one number of healds, and that the same number must be up in successive picks. Should different numbers be up at consecutive picks, a spring top as at S is used.

CHAPTER V.

COTTON CLOTH, CLOTH-LOOKING, VARIETIES, DIMENSIONS, STANDARD MAKES.

IT is for export that the bulk of cotton goods are manufactured, for although the home trade is extensive when considered separately, yet if compared with the foreign trade it becomes unimportant. Goods for export may be classed into a few standard makes of cloth distinguished by some special feature as to length, yarns, finish or other characteristics such as are described later.

Before leaving the mill, the classification of the goods by name receives no attention, the order to which they belong being the only distinguishing description.

Cloth-looking.

The pieces are brought into the warehouse off the mill, by the weavers, and are hooked in folds of 1 yard. This operation is performed on the hooking or plaiting machine, a contrivance which requires little or no special description, as a few minutes' examination of it will suffice to acquaint even a tyro with its construction and working. In some concerns the looking is done on this machine. Probably the cost is lessened and the cutlooker sees the whole of the piece (not missing one side of the "flue," as not infrequently happens in the counter-looking), but the fact that the smaller faults are not all seen renders the advantages questionable, unless the cloth is afterwards counter-looked.

The cloth-looker's duty is to examine each piece of cloth, reporting any fault to the person responsible, and throwing out as seconds the pieces which are not up to quality. The faults attributable to the weaving are:—

Faults in Cloth.

Bare, badly-covered cloth, caused by the back rest of the loom being too low, the shed too large, late treading and picking, too much weight or uneven sheds. Cockly cloth looks raw and has raised lumps on the face caused by too little weight. Cracks are sometimes weavers' faults in not letting back after weft breaking, take-up motion working unequally, or through some parts not being screwed up tightly. The reed case also requires attention in case of this objectionable fault. Uneven cloth is generally attributable to the unevenness of the weft, although anything tending to unequal release of the warp from the beam, such as weights touching the floor, damp ropes, or loose pivots, may cause it.

Reedy cloth is caused when a few dents of the reed are bent out of position.

Bad sides are either slattered, caused by unsatisfactory bottoming, or are frayed and raw from lack of sufficient side ends. Occasionally a bad picker catches the weft and causes a peculiar ridgy selvage.

Floats are the result of obstruction in the shed generally, broken twist keeping down the warp threads and preventing their interweaving with the weft; a raw place is caused which can generally be obliterated.

Mashes are on a larger scale. If the shuttle is entrapped without the reed flying out, in loose reed looms, or the protector acting in fast reeds, the twist is entirely broken out for several inches in the width. To piece up all these ends leaves an ugly place, and it is occasionally preferable to weave on and seam the piece, after cutting out the obnoxious part. A shuttle spelling will cause the same effect as trapping.

Broken picks are caused by several layers of weft coming off the cop into one shed. These should be picked

out by the weaver, as, besides being unsightly, they are objectionable in certain after processes—printing, raising for oilcloth purposes, etc.

In figured work faulty patterns, slattering borders, and missing picks or ends require attention.

Black oil—that is, oil discoloured by being mixed with the particles of iron ground off the shaft necks and bearings —must be washed out with soap and water. Oxalic acid is often applied to the spots, combining with the iron and forming oxalate of iron, which, being soluble in water, can be rinsed out. This substance, unless thoroughly cleansed out, acts somewhat corrosively on the fibre, and for this reason is tabooed by some cloth buyers. In coloured work care must be taken that the colour shows up well and bright. According to the prevalence of any of these faults in a piece of cloth, the cloth-looker has to select and classify his deliveries. Other important items are included in the scrutiny—short lengths and widths, short or uneven weights, too light reed and pick, wrong headings, are all very important points, necessitating careful attention, and instant report of same to the persons responsible.

Headings.

Headings, or cross-borders, are bars of coloured wefts placed at the end of each piece of cloth for distinction from other pieces. These headings are also placed at other parts of the cloth, indicating where the pieces are to be separated by the retail dealers. These headings are very fanciful and intricate in some instances, ranging, as they do, from the simple stripe heading of 2 or 4 picks, to the extensive Sarrie or Madras heading 15 or 20 inches in length. The principal headings are the Bombay, Ceylon, Sarrie, Calcutta, and Madras.

Packing.

After having been passed the goods are made up into portable bundles of about 10 pieces in each, and are

ready for forwarding to the warehouses in Manchester, or possibly to the bleachers or printers, or to some Glasgow or London house. Some few manufacturers have also a shipping connection, when the cloth is packed and forwarded direct without passing through the hands of the Manchester agent. The bulk of the cloth goes to Manchester, and here undergoes a second scrutiny preparatory to packing if shipped "in the grey," or previous to being forwarded to the bleacher, dyer, finisher, or printer, if it has to undergo these processes before export.

Bleaching is the removal of any colour from the cloth by the action of chemicals.

Printing is the colouring of the surface of the cloth according to a figure or design, and may be in several colours.

In finishing, the cloth is coated with filling substances and has a gloss imparted to it, greatly improving the appearance of the fabric.

In such fabrics as cotton blankets, or for the thin oilcloths known as American cloths, the fibres on the surface of the cloth have to be raised; this operation is performed in a raising machine, where, by means of pointed filleting, the face of the fabric is abraded until the fibres form a nap.

In packing, the pieces are arranged in bales and compressed to about half their bulk when loose. The layer of protective material round the bales consists of white paper, brown paper, followed on the outside by black oiled sheets and pack sheeting. Occasionally, linen sheets are introduced between the inner and the outer layers as an additional protection against stain or damage. The bales are hooped in the press.

Varieties of Cotton Cloth.

The principal makes of cotton cloth are given below, together with remarks concerning export, sizing, etc., and at the end a list of the standard sizes is attached. The first group of cloths includes the shirtings, dhooties, and long-cloths:—

Shirtings are heavily-sized goods, 125 per cent. not being unusual. The widths vary from 38 to 50 inches, length about $37\frac{1}{2}$ yards long-stick. Reed and pick from 12 square to 19×18. These goods are made to weight—thus, a 39-inch 16×15 weighs $8\frac{1}{4}$lb.; a 45-inch, 9lb.; a 50-inch 10lb. Various kinds are made, some medium-sized. What is known as Indian shirting is the heavy-sized class.

Shirtings are exported to India, China, Japan, Turkey, Italy, Levant. A good class is made, bleached, and exported to Egypt, Japan, India, and China, as white shirtings.

Dhooties are shirtings ornamented by stripes of grey or coloured yarn, and in suitable lengths for Hindoo loin cloths. The stripes are not of very varied character in grey dhooties, being simply tape edges formed by cramping grey or bleached yarn at the selvage. In coloured dhooties, stripes of vari-coloured warps are introduced about an inch from the edge of the cloth, and varying from half an inch in width to 4 inches, sometimes being introduced at intervals all across the piece. In dobby-dhooties these stripes are woven in figures.

A range of dhooties includes all widths from 22 to 50 inches, and the length of scarf varying from 2 yards in the smaller size to 5 yards in the larger. A scarf is the distance between the headings, which in these goods are very extensive, sometimes reaching to 20 inches in length at the juncture of the two scarves.

A Range =	22	inches and	23	inches	= 2-yard	scarf.
	24	,, ,,	25	,,	= $2\frac{1}{2}$,,	,,
	26	,, ,,	28	,,	= 3 ,,	,,
	29	,, ,,	32	,,	= $3\frac{1}{2}$,,	,,
	35	inches ...	...	...	= 4 ,,	,,

The higher widths being variously $4\frac{1}{2}$ or 5 yards.

Dhooties are made up in about 40-yard lengths—thus, a piece 44 inches wide would contain 4 double scarves. The yarns employed vary similarly to shirtings, from 30/40's warp, 36/60's wefts.

The dress of a male Hindoo consists of a dhootie containing 4 square yards, a doputta of 8 square yards,

and a turban of 12 square yards; whilst in addition the Hindoo woman wears sarrie, a similar cloth to the dhootie. India is the recipient of the dhooties in greatest quantity. Sarongs go to Java, patadiongs to the Phillipines.

The shirtings here mentioned must not be confused with the home trade shirtings—goods in which only the finest yarns are used, free from any of the objectionable filling referred to above. To this class belong long-cloths, mediums, Wigans (plain and twill), double warps and twills. Export long-cloths are plain goods, shirting style, 36 yards long, generally 36 inches wide, 12 square, medium size.

Another group of sized cloths, next in importance to the shirtings, consists of the T-cloths, Mexicans, domestics, and madapollams. T-cloths are always 24 yards in length, of coarse yarns, heavily sized, from 28 to 32 inches wide, 12 × 10 to 16 × 16,* 4lb. and 6lb. in weight. The name is derived from the mark T of the first exporters. Exported to India, China, Japan, South America, Roumania and Servia.

Domestics are from 28 to 39 inches, 60, 72, 80, or 96 yards. Warp, 18/24's; weft, 16/40's; and from 14 to 16 reed and pick; medium to heavy size. Exported to South America, Italy, Levant, Turkey, Egypt. A somewhat better class is made and used extensively by the home trade.

Mexicans are of better quality than the foregoing, and are always above 17 × 17 reed and pick, yarns, twist, coarse; weft, medium; medium size; 28 to 32 inches in width. Exported to South and Central America.

Madapollams are lighter in reed and pick than the foregoing, being about 11 and 12 square; width, 28 to 32 inches, and similar in length to the T-cloths and Mexicans; sized medium. Exported to India principally, also to Mediterranean States and to South America.

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* In this Chapter, where reed and pick is given, it must be understood as referring to a quarter of an inch, unless otherwise specified. Thus—12 × 10 means 12 ends and 10 picks in a quarter of an inch, or 48 ends and 40 picks per inch.

Dyeing and printing cloths form an important department.

Under the first heading Turkey reds are prominent. These, like printers, are cloths of good quality. Shirting counts and widths, but about twice the length; pure size. Exported to Japan, China, India.

Printers, Burnley makes, sometimes dubbed Burnley lumps, are 32 inches, 116 yards, 16 × 16, 32's/50's yarn. Quality important, yarns good, lightly sized, warps even and hard-twisted, weft free from unevenness, snarls, etc.

Glossop printers, 36 inches, 19 × 22; 50 yards, $11\frac{3}{4}$lb.

These are not the only descriptions of printers, coarse cloth of varied dimensions being required, which, when stamped with patterns of every conceivable style, are exported to India, Persia, Italy, Brazil, Levant, Java and Japan.

In light goods, tanjibs, jacconetts, mulls and cambrics may be classed together.

Tanjibs are the coarsest; 30 to 50 inches wide, 38 yards long, 12 square, 32's/40's; lightly sized.

Jacconetts and nainsooks are finer; 39 to 44 inches, 14 × 14 to 16 × 16, 32's/50's, about 20 yards long.

Mulls are somewhat similiar in style; 39 to 50 inches wide, 20 yards, 16 × 16 to 20 × 20, from 60's to 100's yarn; pure size.

Cambrics are the finest of the group; generally wide from 24 square to 36 square, 80 to 160's yarn; pure size.

Turkey, India, China, Japan, Roumania, the Levant, Egypt, are all customers for these four cloths.

Book and tarletan muslins are very fine home trades.

A variety of cambric called embroidery cloth is largely made in some districts. It is of first-class quality, usually about 50 inches wide, and cut up into short lengths. It is chiefly exported to Germany and Switzerland, there to be embroidered by the machines spread over the country districts, and returned as Swiss work, etc.

Sheetings are very wide goods; 60 to 100 inches. The yarns are coarse, generally 12's to 20's, although fine sheetings are frequently made.

Waste plains are coarse goods woven with yarn spun from waste.

Ginghams, checks, zephyrs, although coloured goods, are of plain weave, and of unclassifiable dimensions.

Other plain cloths needing little remark in consequence of their unimportance are:—

Tarletan Muslin	52 inches	40 yards,	13 square
Chambrey	28 ,,	30 ,,	27 × 22
Hair-cord Muslin ...	59 ,,	24 ,,	20 × 22

Warped 1 twofold, and 1 fine single.

Blue Mottle	27 inches	96 yards,	16 × 11

Blue warp, white weft.

Victoria lawns, fine goods, and Taffechelas, formerly important goods, are now in little request.

Cotton cloths other than plain:—

Drills.—Heavy 3-shaft twills, narrow, heavily sized. Exported chiefly to China, few to Cyprus, Levant, Turkey, and Brazil.

Cretonnes.—Printed twill, made from coarse waste wefts, finer warps, various widths, generally narrow. Home trade; also exported to Turkey and British Colonies.

Jeans.—Finer 3-shaft twills, plain borders, narrow, for printing or finishing.

Sateens.—5-shaft broken twills, 30 to 36 inches, 75 to 90 yards, 70 to 96 reed, 40 to 80 picks, 36's to 80's weft.

Velveteens.—Narrow, heavy-picked cloths, from 90 to 120 to the quarter-inch, yarns fine and best quality, 80 to 100 yards. Home trade and general export.

Cords, Fustians, Corduroys.—Heavy, figured cloths, 20's yarn, 90 to 140 picks to a quarter-inch, 70 to 90 yards.

Brocades.—Fancy jacquard goods; 36 inches, 75 yards; 72 to 96 reed, 20 to 26 picks.

Doriah Stripes.—Cloth carrying crammed stripes—not in colour—are often narrow, 26 to 30 inches, 10 yards long, 12 to 30 reed by 13 to 14 picks; yarn, 40/50's T; and finer wefts.

Leno.—Narrow, generally 30 inches; 24 to 40 yards, very variable in reed and pick; yarns.

In white check we find:—

Figured Checks.—30 to 36 inches, 13 × 16 to 18 × 20; 12 yards single cuts.

Satin Check	40 inches	32 yards,	16 × 20
Tape Check	36 ,,	24 ,,	22 × 20
	37 ,,	48 ,,	20 × 24

STANDARD MAKES.

	Width.	Length.	Reed and Pick.	Yarn or	Weight.
Shirtings	39	37½	16 × 15	30/36's	8¼lb.
T-Cloths	32	24	14 × 14	—	6lb.
Mexicans	32	24	18 × 18	—	7lb.
Jacconetts	44	20	14 × 14	40/50's	—
Mulls	50	20	20 × 20	80/100's	—
Domestics	29	80	14 × 14	18/18's	—
Dhooties	44	40	16 × 15	30/40's	—
Printers	32	116	16 × 16	32/50's	—

In this connection, as reliable and comprehensive a list as it is convenient to gather is placed before the reader; although, from the varied character of cotton cloth, many specialities are omitted, such, maybe, as those cloths used in the hat trade for lining, the oilcloths, umbrella cloths, and numerous milliners' and drapery requirements for the home trade.

CHAPTER VI.

FANCY WEAVING, TAPPET AND DOBBY WORK, ANALYSIS OF CLOTH, TAPPETS, CLOTH, DOBBIES, DOBBY CLOTH, GAUZE, HANDKERCHIEF MOTION.

AN important and increasingly successful department of cotton manufacturing is that comprised under the heading of fancy work. Here a great amount of skill and intelligence is necessary, and in the more complicated goods a display of talent uncalled for in the limited and well-trodden ways of plain manufacturing. In fancy weaving not only do we come across the variations of manufacturing details which present themselves in the ordinary branches, but, in addition, an infinite variety of patterns and different designs crowd upon the one side, while on the other an artistic eye is required to combat with and blend the varied groups of colours and shades in harmony and beauty.

A moment's reflection will remind the reader of the great number of the cotton cloths which come under the heading of fancies, and for purposes of convenience we must treat of them under the headlines of three chapters —Simpler fancies, Jacquard and complicated fancies and Checks.

Classification of Cloth.

Woven fabrics of any material may be divided into four main classes :—Plain, figured, gauze and woven pile cloths ; laces formed on an entirely different structure being disregarded.

Plains show no figure of any nature on the face of the cloth, have every end and pick interwoven alternately, while the warp forms a right angle with the weft. Apparent figures, ribs and stripes may be made by using fine and coarse weft or alternate counts of warp. Stripes or checks of colour may be introduced, but if the weave be unaltered the cloth still is classed as plain.

Figured is a very comprehensive group, consisting of the twills, sateens, velveteens, figured borders, figured checks, damasks, brocades, dimity, weft pile, counterpanes, fustians, cords, etc., and almost all fancy cloths, except gauze and warp pile.

Gauze has a peculiar structure, pure gauze differing from plain cloth in the ends, weaving at an angle more acute than a right angle. Leno is one kind of gauze.

Woven or warp pile cloth has a nap woven on the face and cut whilst in the loom—a class of cloth not frequently met with in cotton, but generally in the silk and carpet trades.

Analysis of Patterns.

For purposes of reference and communication some method of representing cloth patterns on paper is necessary, and the one generally adopted is to use point

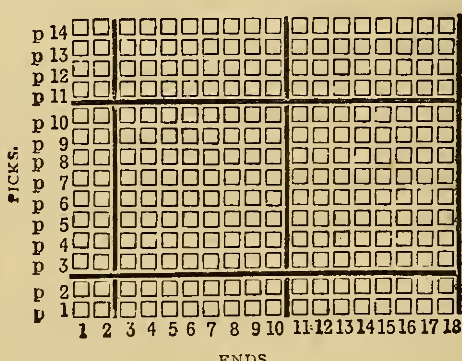


FIG. 29.

paper ruled in small squares by thin lines; bolder lines group the smaller into larger spaces, generally 8 by 8, as

shown in Fig. 29. Assuming that a row of horizontal spaces (not lines) represents a pick of weft, and correspondingly a row down the paper is indicative of a warp thread, a cross or mark is made where the twist shows on the face of the cloth. Thus, Fig. 30 represents plain cloth.

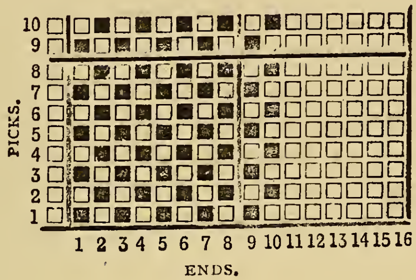


FIG. 30.

Referring to Fig. 30, and following each pick across, we find that first the warp and then the weft rise, and by

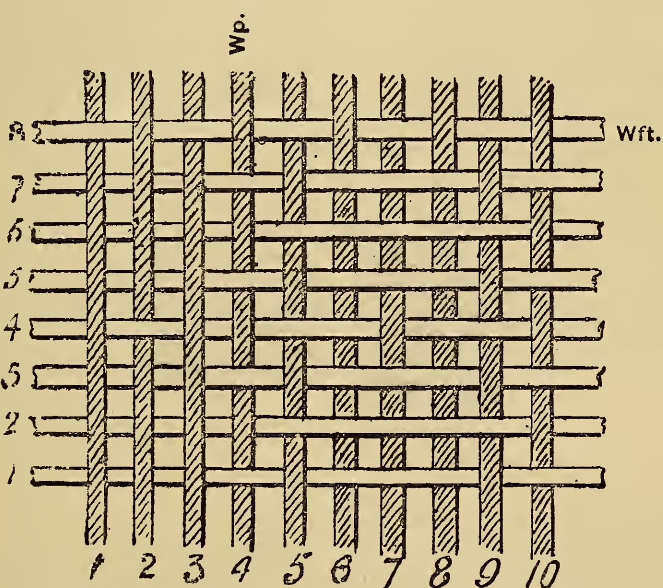


FIG. 31.

tracing any end we see that it floats over and under the weft alternately—this giving the well-known plain weave.

Wherever the warp shows, a cross is made in that intersection. The cross is only used for convenience. When a design has to be properly shown the whole of the intersection must be filled up thus : ■

Advocating the method of placing a ■ for a twist riser is a departure from the rules of some authorities on weaving in the past, and also from the system adopted in other textile industries at the present. The reason for adopting the system mentioned is, that for most cotton fabrics it is advantageous in facilitating the reading of the design, for pegging in Keighley dobby, card-cutting in the jacquard, planning tappets, in showing up some classes of designs more clearly, less work in marking some ground

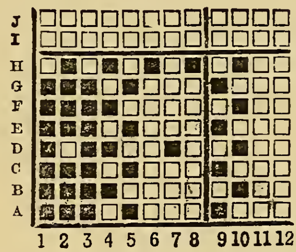


FIG. 32.

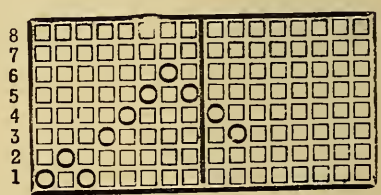


FIG. 33.

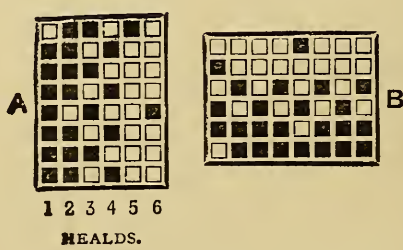


FIG. 34.

cloths with preponderating weft, and in other technicalities, the whole of which compensate for the disadvantages of the system in some few classes of cloths where a designer uses the alternate system of ■ weft riser at his convenience. In reference to Fig. 30, the beginner will clearly under-

stand that the marks or crosses show the warp on the face of the cloth with the weft underneath it. The same square if left blank would show the weft on the face with the warp beneath it. Thus, the row of marks numbered 1 in Fig. 32 shows number 1 warp thread floating over 7 picks out of 8, and the row of blank space numbered 8 shows the weft over warp thread number 8 for the space of 7 picks out of 8.

The cloth shown in Fig. 31 has its representation on point paper at Fig. 32, the numbers attached to the threads corresponding with the rows of spaces in the design.

In transferring a pattern from a piece of cloth to point paper, a beginner would pin it to a board, mark an end of warp, say No. 1 in Fig. 31, and commencing with the bottom pick 1, mark crosses on his point paper where the warp shows at any square in that pick—thus, at the 1st, 2nd, 3rd, 5th and 9th ends—working upwards to the next pick, starting at the same end. Similarly a second pick is put down on the point paper above the first, always working in one direction, say from left to right. This is continued until the pattern begins to repeat itself, as at pick 9, when it is complete. A pattern is the least number of ends and picks on which a cloth can be woven, the picks or ends of a second pattern being facsimilæ of the first.

The analysis or pricking of patterns is performed by an experienced man without the tedious process of pulling the cloth asunder, the pattern being read from the face of the cloth by means of a cloth-glass.

Designing.

Designing (actual) is a very different process. A figure or figures of some character must be originated suited to the class of cloth for which it is intended. This is first sketched on plain paper, called a rule, painted (if colour be desired), and having due regard to economy in the weaving, it is tranferred to point paper.

This is done by ruling the design in inch squares, and

should the reed and pick per inch be equal, 8 × 8 paper is used; if the reed and pick are in proportion to 8 and 6, 8 and 10, 12 and 8, or any other ratio, point paper of that size is used, and the figures will appear in the cloth proportioned as in the rule. The leading figures of the pair of numbers are, in jacquard work, always equal to the number of rows of needles, thus 8 × — is for a 400 machine, 12 × — for a 600.

Drafts.

After having obtained the pattern of a cloth it is necessary to draft the ends on the least number of healds on which the cloth can be woven. Drafts are represented in various ways—*e.g.*, by drawing lines representing the healds and marking the order in which the ends are drawn on them; thus, if the first end be drawn on the first or front heald, the second on the second heald and so on, we get a straight draft as shown in Fig. 35.

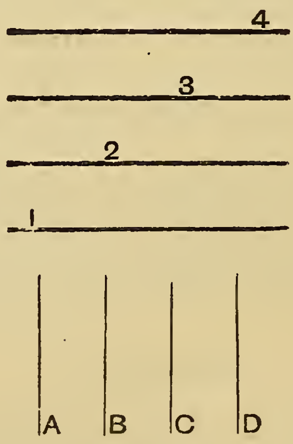


FIG. 35.

The numbers represent the heald on which the end is drawn. The ends are lettered in their order.

Should the first end be on the first heald, the second

end on the third heald, the third end on the second heald, the fourth on the fourth heald, we get a skip draft—thus:

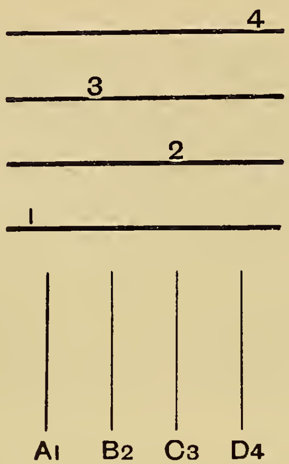


FIG. 36.

In practice it is usual to omit the lines and just give the draft, thus:—

4
3
2
1

This is a very convenient method of representing a draft for the use of the drawer-in or the weaver, but when using point paper it is better to reserve a few picks above the design to represent as many healds and indicate on which the end is drawn by making a small circle. Thus, a honey-comb design is shown in Fig. 37, A. It can be reduced to and woven on 8 picks and 8 ends, as at B, the pattern; the draft is shown at C, the 8 ends being drawn on 5 healds. Below is shown the method of obtaining these plans—a study of which remarks will enable the reader to perform similar work for other cloths. Commencing at the first end on the left-hand side, it is placed on the first heald, H 1; looking across the pattern

we find no other end working like it. Proceeding to the second end, it is placed on heald number 2, and as the eighth end works like it, it is placed on the same heald

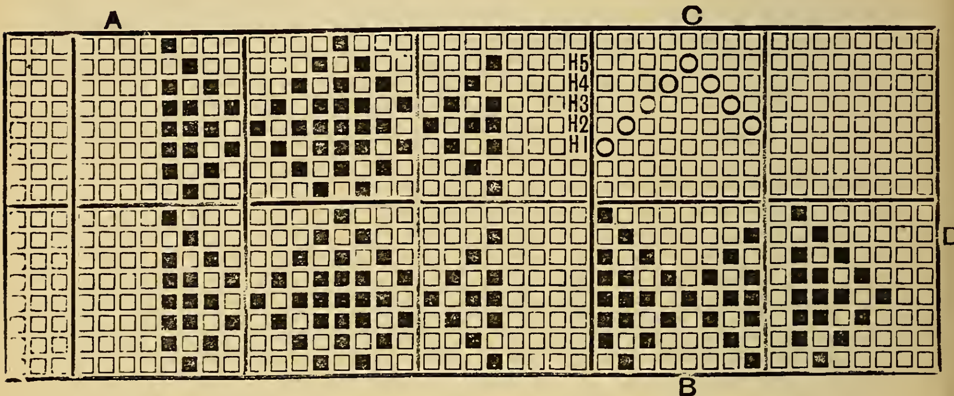


FIG. 37.

shaft. The third and seventh ends are marked for the third heald. The fourth end working differently to any other except the sixth, these two are placed on H 4; whilst the fifth end only is left for the fifth heald. This draft, from its appearance, is dubbed a point draft or V draft.

Lifting Plans.

It is now necessary to indicate when the healds shall be lifted to make the cloth with the given draft. A portion of the point paper is taken as many spaces wide as there are healds, and as long as there are picks to the round.

Taking Fig. 37 again, for example, we find the lifting plan at D, the ends and picks being numbered. The marks indicate where the heald has to be lifted at the pick indicated; thus, taking the first heald, we find it to be lifted at the 2nd, 3rd, 4th, 5th, 6th and 8th picks, a working necessary for the first end, which is drawn on the heald in question. The pegging plan for a dobby is a modification of this. (See page 106.)

For a straight draft the pattern is exactly a duplicate of the lifting plan. Other names for this plan are tie,

working design, treading plan, and shedding plan. The tie is a plan serving the same purpose of the lifting plan, but somewhat differently arranged, the end being laid hori-

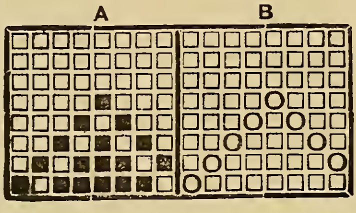


FIG. 38.

zontally in a line with the heald through which they are drawn; thus, for the honeycomb, Fig. 37, the tie-up is shown at Fig. 38, in which A is the tie-up.

The lifting plan for Fig. 32 is shown at Fig. 34, A, while the tie-up is shown at Fig. 34, B.

Shedding.

The principal motions for shedding—*i.e.*, raising the ends in the required order for producing the desired weave of cloth—are tappets, the dobby, and the jacquard. The tappets and the dobby are described in this Chapter. The tappets, which have the smaller range of work, are taken into consideration first.

Tappets.

For the simpler classes of fancy weaving, designated stavework, tappets are often used. These are arrangements of plates carrying projections to raise the healds when required, the plates being placed so that the projections in several plates which are to act at one pick are in line with each other, so as to raise the different healds at one and the same time. Tappets are fixed either above the loom (and are named motions or Jamieson's tappets), or at the side of the loom—as, for instance, the Woodcroft tappets. In some cases, for

three and four-shaft twills, under-heald tappets are used, and fixed on the twill-shaft previously referred to (page 76). In setting out a tappet—for a sateen motion, for

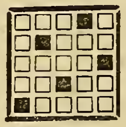


FIG. 39.

FIG. 40.

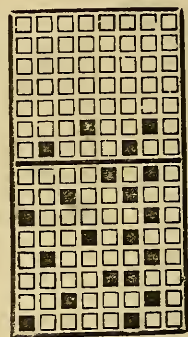


FIG. 41.

instance—first get our pattern, Fig. 41, which is composed of Fig. 39, a satin, and Fig. 40, a plain for the selvage. Fig. 41 is the pattern on 7 healds and 10 picks to the round, that number being the least that will contain both 2 and 5 without remainder. The draft being straight over the pattern is also the lifting plan, and the first plate is required to lift the healds at the 1st and 6th picks. Dividing a circle into 10 parts, we take the first part, and allowing half a revolution of the crank-shaft for dwell, obtain an inclined portion C for the raising, and D for the depression of the heald (as described in Chapter IV.), by dividing E C into six parts, and describing six arcs of a circle, afterwards drawing a line diagonally. The tappet follows the circumference of the inner circle until it arrives at the 6th pick, when another projection must be raised. The complete tappet follows the form shown by the thick line.

It will be seen now that, as the tappet only moves $\frac{1}{10}$th of a revolution for one pick of the loom, the heald connected with this plate will be actuated just as is required in the treading plan.

Four other similar plates must be cast for the other satin healds, which five will be bolted together so as to have projections at the 1, 3, 5, 2 and 4 picks, as shown at A. To these are bolted two plain plates, or, as is more usual,

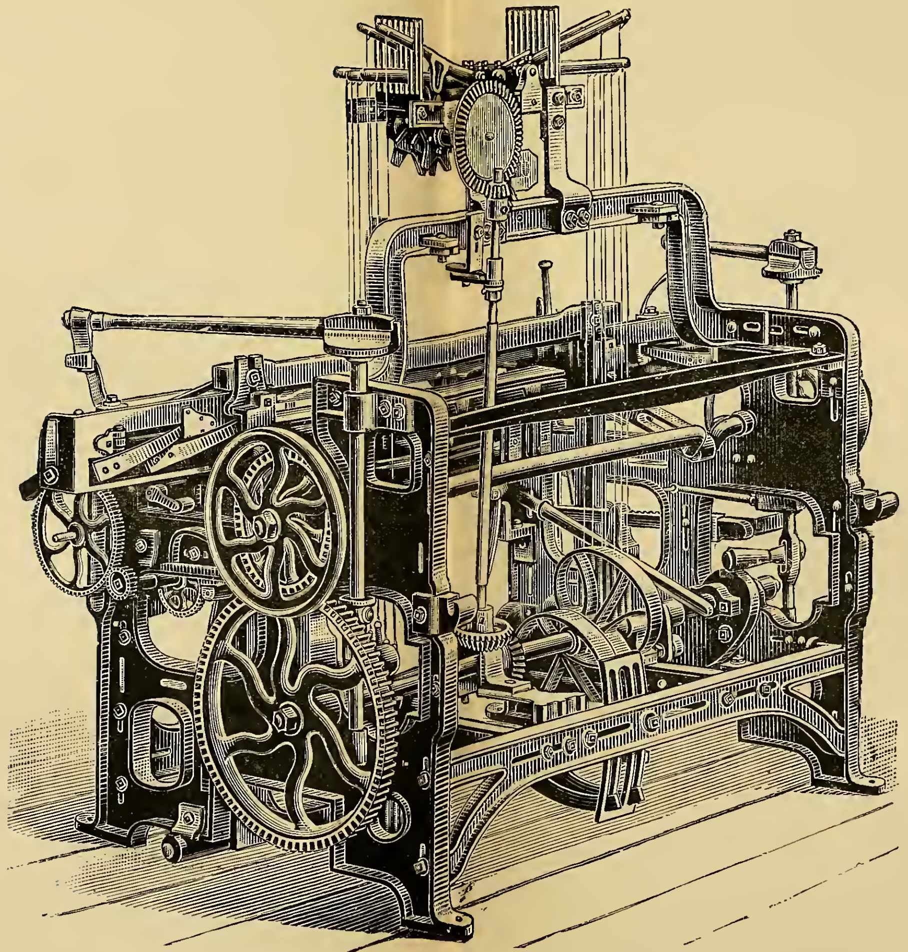


FIG. 43.—LOOM WITH SMALLEY'S MOTION.

To face pp. 98 *and* 99.

one casting equal to the whole seven. The plates for plain show an alternate projection and space. By the kindness of Messrs. Willan & Mills, of Blackburn, a sketch of their loom with one of these motions (Smalley's patent) affixed to it is shown.

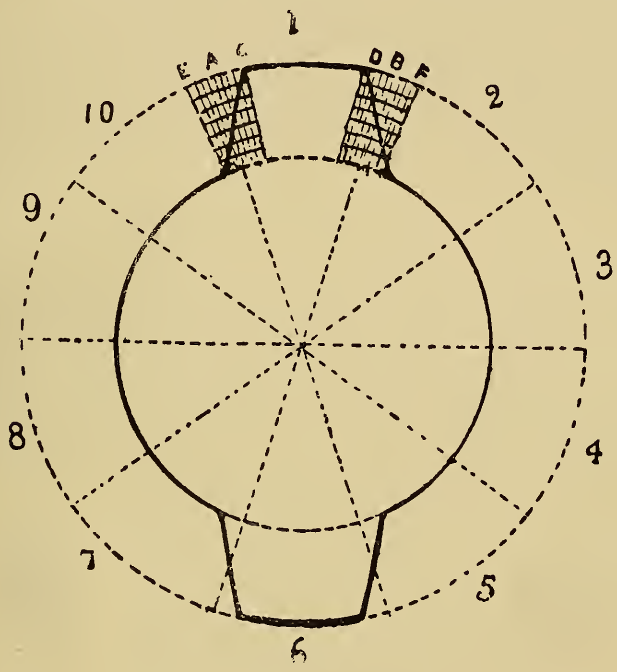


FIG. 42.

The tappet is fixed on the upper frame-work of the loom and short treadles arranged above it. To these the healds are attached and lifted by the plates, being drawn down afterwards by springs and the healds. In a recently-improved form the treadles raise the jacks to which the healds are attached, giving a straight lift. These tappets are seldom used for more than 8 healds and 12 picks to the round. Above this extent in tappet work, a Woodcroft sectional tappet is used, arranged at the loom side. In these tappets the projections (called risers and fallers) are removable, the tappet being adaptable to different patterns up to 14 staves and 20 picks. In the Yorkshire loom,

Fig. 23, the tappets are placed at the loom side, and are connected with the top of the healds by rods.

Tappets possess the advantage over other shedding motions of larger capacity, such as the dobby: (*a*) in lower first cost; (*b*) steadier and stronger lift without risk of hooks slipping; (*c*) in having a split shed—*i.e.*, a shed which has one portion pulled down while the other is drawn up, saving time. Dobbies and jacquards generally have a sunk shed, and if by those machines a shed 2 inches deep is required, the lifting knives have to be raised the whole distance, from the bottom to the top.

Cloths Woven by Tappets.

Among the cloths woven on tappets there are twills, cloths in which a figure is woven diagonally across the cloth by raising the healds consecutively. They are in large variety, being woven on three shafts upwards and not confined to the lifting of a single heald at each pick; as in some cloths two or three out of a larger number

FIG. 44.

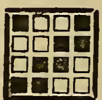


FIG. 45.

may be raised, but the same number is up at every pick, although moving one end or more at each pick. A serge is a modification of a simple twill woven in this manner. Fig. 44 represents a 4-shaft twill rising one in four, while Fig. 45 shows a 4-end twill rising two in four, called a denim, swansdown, or cashmere twill. The satin weave is a broken twill—that is, instead of lifting consecutively at each pick, an end, or in some cases two ends, are passed over, as shown in Fig. 39 (sateen). The ends are lifted in this order: 1, 3, 5, 2, 4. A 5-stave, showing a weft satin, is the standard for *sateen*. The satin or broken twill applies to any number of twill staves—*e.g.*, a 12-stave satin, passing 4 ends over, lifts 1, 6, 11, 4, 9, 2, 7, 12, 5, 10, 3, 8.

A perfect satin never shows contiguous ends lifting together, as such would give a "spotty" appearance. As almost all the weft shows at one side of the cloth, the parallelism of the threads gives to this weave its well-known lustre, but unless fine yarns and reed with heavy pick are used a very frail structure is the resultant.

Stripes are of various kinds. The herring-bone or reversed twill forms an undulating pattern by using a point draft. Simple figures, on not more than six or eight staves, woven cramped between stripes of plain, are called doriah stripes.

Pile Cloths.

Velveteens are woven by motions similar to the one in Fig. 46, generally on six staves. The object aimed at in this cloth is to produce a firm ground cloth with picks of pile weft floating over several ends of warp. Pile picks are inserted between plain or twill ground picks and are

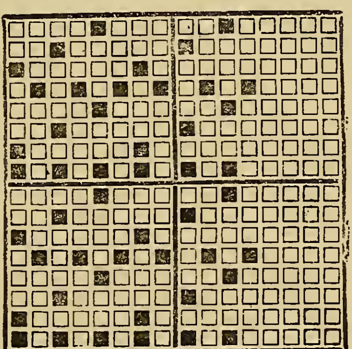


FIG. 46.

firmly bound in at intervals, so that when the floating portion is slit by the cutter the pile threads will not be loose. In the uncut cloth a slight rib of weft is seen transversely. A pattern of velveteen is given at Fig. 46. Velveteen is classed with the figured cloths, for as it leaves the loom it presents no appearance which warrants other classification. The fourth class of fabrics—woven piles—

is woven in an entirely different manner. A wire is inserted in every fourth shed instead of weft; picks of weft are then put in and the wire withdrawn. As it carries a knife, the loops of warp over the wire are cut as it is pulled out, leaving a pile on the cloth, the length of which is perfectly regular, differing from the weft pile velveteen in this respect. The wires are inserted and withdrawn by additional mechanism attached to the loom.

Cords, Fustians.

Cords, moleskins, corduroy, fustian, bull-hides, thick-sets, are all pile fabrics of a heavy character. The pile is all in the weft floating upon a ground cloth. Different makes of each fabrics are woven and named frequently according to the style of this ground or backing weave—*e.g.*, tabby back means plain, Genoa is a 4-end twill, Jeanette is a 3-end twill, double Genoa, double Jeanette. Woodcroft tappets are chiefly used in the production of these cloths. The cords show a broad wale or stripe running lengthway of the piece, consisting of weft floating over the warp and ground cloth, and in such a manner that when slit along the centre of each stripe the divided threads stand up to form a cord. The weft of the next wale being cut similarly, a stripe of pile fabrics is now formed, having its centre above the groove which divided each stripe of uncut yarn.

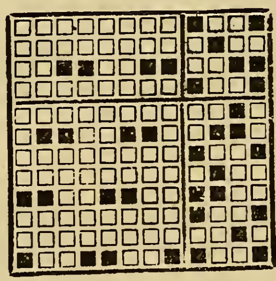


FIG. 47.

A rounded effect is given to these cords by having the threads forming the centre of greater lengths than the

sides of the cord, they having had a longer float in the weaving. This cloth is dyed and finished, being sold as corduroy.

Cords are of several kinds, one class named "constitution," of which a pattern is given at Fig. 47, on 12 ends and 12 picks, requiring 8 staves to weave it. The constitution is the broadest cord, the thickset cord being the finest, whilst 8 and 9 shafts, bang-up, Mellor's round top and cable cords are names given to other varieties.

Constitutionals are generally made on 8 shafts; yarns, 30/2 fold twist; 16's to 20's weft; 120 to 140 picks to a quarter inch; 36 to 44 reed, Stockport; 31 inches wide, 100 yards long. Cables are on 10 and 12 shafts. Thicksets are on 6 ends and 9 picks, 30 inches wide; 30 to 44 reed, Stockport; 90 to 120 picks to quarter inch; 14's twist, 22's weft. In imitating skins of animals the bull-hide weave is resorted to either for beaver or lambskin finish; woven on 8 ends and 8 picks. Moleskin is a smooth, solid cloth, and, before finishing, shows a very slight longitudinal rib which distinguishes it from the cotton velvets, which have a transverse rib. Moleskin is often called velveteen, although not correctly so; really, velveteens are the cotton weft pile velvets previously described.

These classes of cloth are woven with the non-positive or drag take-up motion, which draws forward the cloth as it is knocked up by the slay. A catch is raised by the rocking shaft of the loom, and actuates by a ratchet worm and wheel the cloth roller. The catch is only weighted sufficiently to draw the cloth forward when it is knocked up, thus not acting when no weft is in the loom.

There is a heavy cloth woven from coarse (waste) yarns named cotton blankets or cotton flannel. This fabric passes through a raising machine, in which its surface is scratched by pointed steel teeth. It is exported chiefly.

Double cloth may be woven by tappets, but as it is more frequently done in the dobby, we will consider it in connection with that machine; the same may be said of some spots, handkerchiefs, and other goods.

Dobbies.

These shedding motions, in principle, perhaps, bear more relation to the jacquard than to the tappets, but are included in the same chapter as the last in consequence of their frequent association in the same shed of looms, both being adapted for stave work.

The dobby, for very many classes of fancy cotton cloth, has gained a reputation as a good shedding motion, and is well worthy the attention of a student of this branch of industry. Its capacity is superior to tappets, extending to 40 shafts, and over two hundred picks to the round in some makes.

The machine is fixed above the loom, Plate VII., giving a direct lift to the healds, which are kept down by springs or dead weights.

Dobbies are occasionally of single lift, but in the cotton trade far more frequently double. The difference is in the double lift having two sets of knives: either knife can lift any heald, and, by duplicating, a second knife can be preparing for and even commencing to lift a heald as the first drops; it thus saves time and increases speed. In single lift machines only one knife is used, and in case of a heald having to be raised two picks in succession, it would have to be dropped to the bottom of the shed after the first pick, and raised again. A double

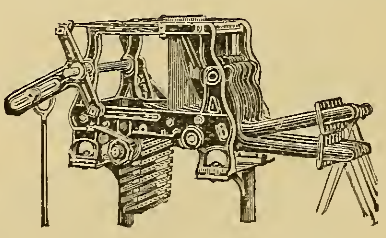


FIG. 48.—KEIGHLEY DOBBY.

lift Keighley is often called, in error, a single lift, in consequence of only one shedding rod being used; it however lifts twice in one complete stroke. Dobbies

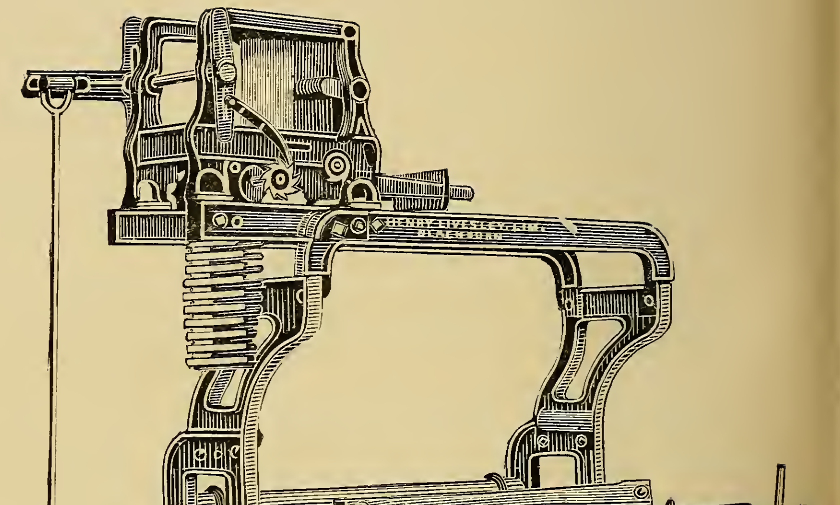


FIG. A.

PLATE

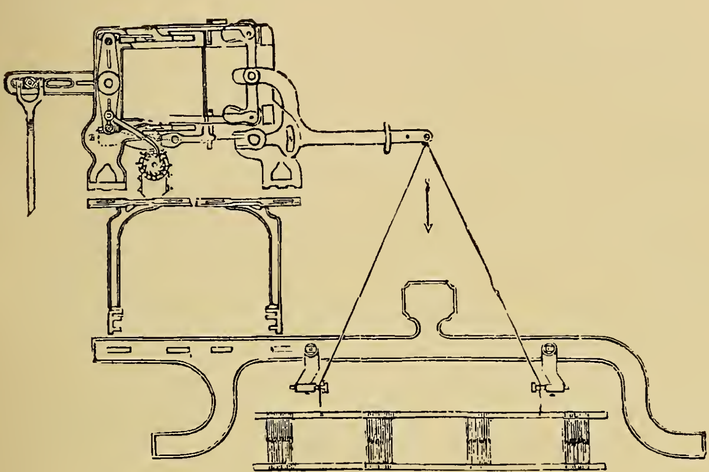


FIG. B.

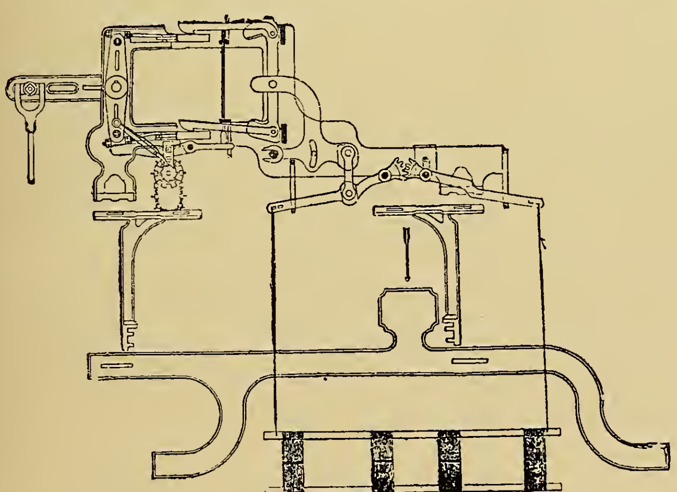


FIG. C.

VII.

To face pp. 104 *and* 105.

have the advantage over tappets in increased power of weaving fancier cloths, a greater number of picks to the round, and a possibility of changing to other patterns.

The leading characteristic of dobbies is, that by means of pegs placed in revolving lattices, any heald can be selected and raised by the machine.

The favourite dobby is the improved Keighley, first patented in 1867 by Messrs. Hattersley & Smith, of that town—it was used to a considerable extent, but recent improvements have greatly increased its value. Plate VII. and Fig. 48 show a general view of the machine—one of Henry Livesey's, Limited, make, on Ward's principle, 20 jacks, double lift. At the under side is seen a pegged lattice; immediately above the pegs and resting on the topmost lag is a row of levers, double the number of shafts or jacks representing the capacity.

The —| knife lever works on the centre shown, and slides the knives backwards and forwards in grooves at A and B.

The jacks to which at one end the heald cords are attached have at the other end latches fixed to them, which are out of the way of the sliding knives, unless purposely dropped on to them.

When a lag is in gear without any pegs, none of the latches touch the knives, and there is consequently no raising of the healds. If all the holes be pegged, one end of each lever is raised, the other end depressed, and consequently all the latches drop on the knives; at the next stroke of which all the healds will be lifted.

By pegging a few of the holes, say the 1st, 3rd, and 10th, we should find only those three healds lifted; in this manner any desired working of the healds may be obtained. The lattice is made up of lags, each of which suffices for two picks, and as the barrel of the dobby will not hold less than 8 lags, a pattern of 16 picks or more is required, unless a smaller pattern be repeated.

In pegging, the lags are placed so that the lattice stands as in the machine, thus:—

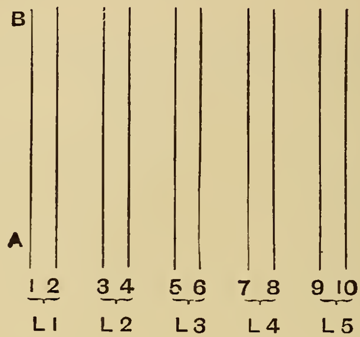


FIG. 49.

Numbers 1 to 10 indicate the picks; L 1 to L 5 indicate the lags.

In a left-hand machine the numbers here given (Fig. 49) represent the order of the picks, the lattice when in use moving over to the left. B indicates the peg-hole for the back-jack, the front or first jack being at A, and the other holes ranging between; there are two rows of holes on each lag, each equal to 1 pick.

Taking Fig. 37, showing lifting plan which occupies 5 healds and 8 picks, the pegging for this dobby will be as under, the small number indicating where the peg is placed and which jack is lifted, the picks being also indicated:—

	•	•	5	•	•	•	•
	•	4	•	4	•	•	•
•	3	•	3	•	3	•	•
2	•	2	2	2	•	2	•
•	1	1	1	1	1	•	1
1st pick	2nd pick	3rd pick	4th pick	5th pick	6th pick	7th pick	8th pick

FIG. 50.

PEGGING FOR HONEYCOMB, LEFT-HAND DOBBY.

As at least 16 picks are required, a lattice would be prepared for 8 lags, 4 being a repeat of those given.

For the other hand of dobby the pegging would commence at the right hand for the first pick, and move towards the left.

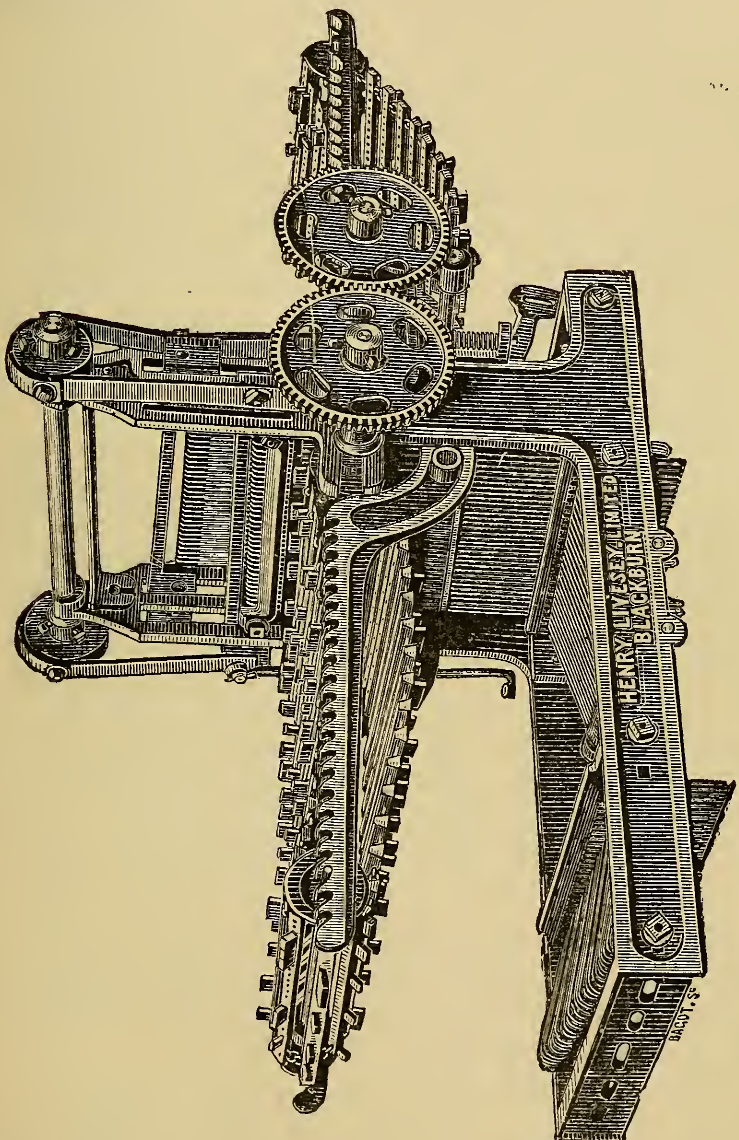


FIG. 51.

The tie-up, shown in Fig. 38, A, is correct pegging for a right-hand Keighley or Ward dobby, as is also 34, B.

Among other makes of shedding machines the common dobby or witch machine may be mentioned. It is of earlier invention than the Keighley, patents having been taken out for it at varying dates from 1830 to 1850. In it the knives slide vertically; there are two lattices, all the odd picks being on one side, the even ones on the other, and a peg indicates a faller—contrarily to the Keighley.

A sketch of a double-lift machine on this system, called by the makers a Blackburn dobby, is shown at Fig. 51.

The connection of the jacks with the lifting knives is made by hooked wires, 2 wires to each jack. Where there is no peg these hooks are in position over the knives; thus, whichever knife should lift, the jack will be lifted by one of the two hooks. Where there is a peg, however, the wire is pressed back slightly, sufficiently so as to remove the hook at the top of the wire away from the knife; and there is no lift for the jack to which the wire is attached.

The pegging for a Blackburn dobby of pattern Fig. 32 is shown in Fig. 52, which represents six jacks and four lags on each side of the machine, a lag in the Blackburn dobby only carrying the pegs for one pick. The large figures indicate the picks and the smaller ones the jack pegged for the picks against which they stand.

·	·	·	·		·	6	·	·
·	·	·	·		·	·	·	5
4	4	4	4		·	·	·	·
·	·	·	·		3	3	3	3
2	2	2	2		2	·	2	2
1	1	1	1		1	1	1	·
7	5	3	1		2	4	6	8

FIG. 52.

The Keighley is generally preferred by practical men for its strength and less liability of getting disarranged or broken. Other makes of dobbies are made, resembling in principle one or other of the types given.

Cloths Woven on the Dobby

Include all makes from plain to 40-shaft patterns. Stripe patterns of the character described on page 101 are

frequent; indeed, this shedding motion is useful for stave work of all kinds, including:—

Spots or Brilliantes—Small figures woven in the fabric at regular intervals, often made from 10 to 14 shafts, on a plain ground. Also, cotton dress materials woven in figured stripes, or a combination of stripes to form figured checks, spot figures, satin stripes and checks, spot figures on plain satin or oatmeal ground—the latter weave being used frequently in fancy cloths woven with coarse yarn, the effect being to show short floating ends apparently irregularly on the face of the cloth, and thus a rough appearance is imparted. The oatmeal weave is in different styles up to 40-shaft.

Double cloth is not now often made in cotton, except for pillow slips, light bags, and similar cloths.

The semi-double cloth of the Yorkshire trade, formed by having an extra weft or warp for putting a cheap back to the cloths, is not known in Lancashire; the extra weft of the velveteen being most nearly approaching the principle. In plain, double cloth weaving, both warps are on one beam, four healds being employed, each movable, independent of the others. Two healds carry the top cloth ends and two the bottom cloth. The shuttle first puts a pick in the top cloth, passing over three ends out of four, all the ends for the bottom cloth being down and half of the top cloth ends; then all the top cloth ends are raised with half of the bottom cloth ends, the shuttle passing under three out of four, and throwing a pick into the bottom cloth. The ends of the top cloth are drawn in the first and second healds, those for the bottom in the third and fourth, thus—

```
B————————4
B——3—————
T—————2——
T—1——————
```

and are lifted as under:—

4th pick = Nos. 1, 2, 3
3rd pick = No. 2
2nd pick = Nos. 1, 2, 4
1st pick = No. 1

The pegging being—

.	*	.	.
.	.	.	*
.	*	*	*
*	*	.	*
1	2	3	4

The selvages are bound by the weft passing from the upper to the lower cloths, and *vice versâ.*

In some cloth, for bags, plain weaving of all the ends is resorted to at certain points to seam up the cloth. A three-stave twill weave may be used by arranging the draft and pegging for six healds or a five-thread satin on ten healds.

Figured Dhooties.

In no stripe pattern, perhaps, is the dobby more generally used than in these cloths. They differ from the ordinary plain dhootie in having coloured ends woven to a pattern along each selvage, or occasionally 12 or 15 inches from the side also. The patterns at each side are balanced—that is, similar in figure, with the inner part of the figure at one side being also the inner part at the other side. This style of cloth may be described as figure with extra warp, for the plain weave extends under the figure, the figuring ends being "cramped" between the plains, and bound by passing through the plain cloth. In designing for these the plain end may be neglected.

The width of the coloured border is generally about 1 inch, although extending to 4 inches in special cases.

The beams are warped in the manner described for plain dhooties, but only the grey ends are drawn in the healds with any coloured warp which has to weave plain. The ends which form the pattern are drawn through harness composed of separate leashes and mail eyes, each with an elastic thread tied to them. These we will refer to as the leashes. They are placed behind the healds and tied as required to the jacks above; the elastic cords are fixed to a bracket below, so as to draw down the leash after the shedding. Above the mail eye is fixed a cumber board perforated with rows of small holes, and used for keeping the leashes in proper order, so as not to become entangled in the weaving. A clear pattern is a great desideratum in this cloth, consequently it is generally woven face down to prevent spoiling face by drooping ends. In pegging for

it the wrong side of the cloth is taken, a pattern of it obtained from the coloured figuring ends only in the usual way, and drafted on the required number of jacks. The leashes are drawn through the cumber board about 6 in each row, but so arranged as to have all those to be tied to one jack drafted together.

The ends are drawn through at the drawer-in's frame, and the leashes having been previously looped in bunches, each bunch containing those intended for one jack, the beam is ready for the loom.

In gaiting up, the coloured ends often pass over a small special back rest, and the bunches of leashes are tied to their respective jacks. By pegging the dobby in the required order any desired jack or jacks may be raised, and those ends kept above the plain cloth. When the jacks are lowered back the same ends will weave below the plain cloth. The body of the cloth is generally of plain weave, although stripe and check patterns are occasionally introduced.

Gauze and Leno Cloth.

This class of fabric is frequently woven by means of the dobby, although the tappet and jacquard are occasionally used should the pattern come within the scope of

FIG. 53.

either. The peculiarity of gauze is, that some of the warp ends cross over one or more of the other warp ends

between the picks, giving an open fabric, sometimes of a beautifully delicate nature, and yet strong, considering the

FIG. 54.

small amount of material used. When gauze weaving is combined with plain it is styled leno. The latter name is sometimes erroneously attached to the gauze itself.

Fig. 53 shows a pure gauze in plan, and Fig. 54 the same in section.

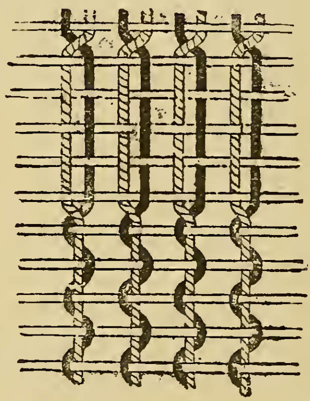


FIG. 55.

Fig. 55 is the plan of a leno. The threads marked heavily in each case are the crossing threads. It will be noted from Fig. 54 that the crossing thread passes up alternately at each side of the backing thread, pick by pick.

The operation of crossing is performed by doup healds. In these an additional loop or half heald carrying a stave at the bottom is slung through the eye of an ordinary heald (Fig. 57). For the purpose of description, the whole of this heald will be termed the doup. This heald is used for crossing purposes, while two or more ordinary healds are provided for the purpose of varying the working, if

necessary. The draft for cloths, Figs. 53 and 55, is as shown by Fig. 56. The crossing thread is drawn through two healds and passes under the backing thread as shown.

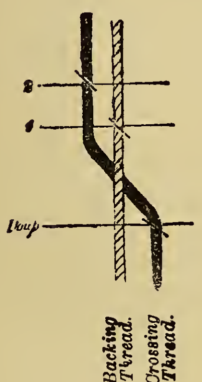


FIG 56.

FIG. 57.

However, the heald No. 2 can be used to raise the crossing thread on the left-hand side of the backing thread, although it is drawn to the right of it at the front, as whenever the back heald is lifted, the loose stave of the doup is lifted also, and the crossing thread is thus free to be wrought by No. 2.

The weaving of the plain is performed by either No. 2 and the doup, or by Nos. 1 and 2. In weaving the gauze portion, healds No. 1 and the doup are used only.

Four jacks are required—one for the back heald, one for No. 1 heald, one for lifting the whole doup when weaving gauze, and a fourth for raising the half loop when necessary to release the crossing thread.

To weave the design Fig. 55 with the given draft, at the bottom pick No. 2 heald and the loop will be raised, at the next pick above the whole doup requires lifting, at the third No. 2 and the loop, at the fourth the doup, at the fifth No. 2 and the loop, at the sixth the plain commences and the doup is raised, at the seventh No. 1 is raised, eighth the doup, ninth No. 1, tenth the doup, which completes the pattern, the eleventh being a repeat of the first.

It is not necessary that the crossing should be round one thread only, but may be round three or four; to do this, of course, the crossing thread would have to be drawn under three or four backing ends in the healds.

The crossing may also be in opposite directions, say—

```
( ) ( )
) (  ) (
( ) ( )
) (  ) (
```

FIG. 58.

as in Fig. 59, where the crossing thread passes over two backing ends. Every alternate end is, in this case, douped contrarily, the same healds being used—the difference being made in the draft. This style is called netting.

All the patterns hitherto mentioned have been single doups. A more highly-ornamental class of goods is made in double-douped cloth. Here two-doup healds are used, and, consequently, half of the crossing threads may be weaving plain at the same picks that the others are douping, and then a reversal is made—the first half commencing to doup while the other section is weaving

plain. Thus, check patterns are made alternately gauze and plain. Double-douped netting and stripe patterns may also be made. With a single doup, only stripe patterns

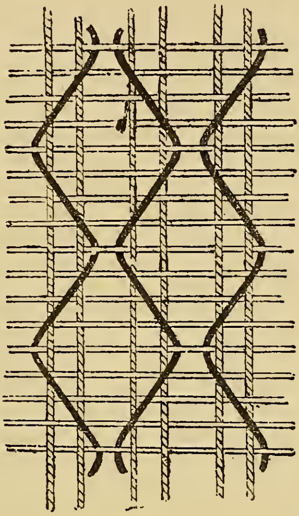


FIG. 59.

may be produced with the gauze running either transversely or longitudinally. For more complicated patterns three or even four doups are employed.

Gauze patterns are not generally marked on paper as are other fabrics, but sketched thus :—

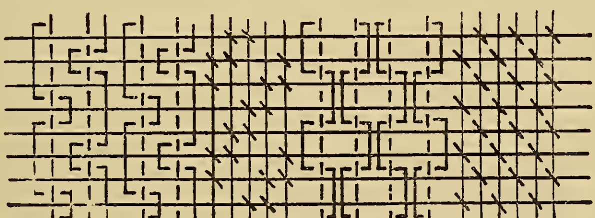


FIG. 60.—GAUZE SKETCH.

Handkerchiefs.

Handkerchiefs are made in cotton, either by the drop-box, the dobby, or by a handkerchief motion. We are referring now to those made without colour, with ribbed

side and cross borders. A stripe border is made by warping the necessary coarse ends (to form the selvage) with the plain ends. To put in the cross border, either the drop-box loom is used with two or more shuttles having different counts of yarn, or, as is more general, the shed is kept open for the reception of several picks of weft in the same counts as the body of the handkerchief. This is easily done by the dobby, which also continues to hold the weft at each selvage by a few plain ends worked from a different jack, or by a catch cord.

It is impossible to have a lattice with as many lags as there are picks from heading to heading, consequently lags are pegged to weave the heading only, the lattice being stopped during the time that the plain body of the handkerchief is being woven. In the double-lift dobby it is possible to stop it, so that the pegging of the lags where the motion of the lattice is arrested will suffice to weave plain until motion is again communicated to the lattice.

Sometimes a special handkerchief motion is used. In this arrangement a chain of lags is arranged, each lag having holes for three pegs. By means of this motion, which is shown in Fig. 61, "a border can be obtained without drop-boxes or dobby, *and without reducing the speed of the loom.* The tappets, which are of the usual form for plain weaving, are not secured to the tappet shaft, but are driven from it through the medium of a clutch, which, when disengaged, allows the shaft to continue revolving whilst the tappets remain stationary; thereby enabling any required number of picks, even or odd, to be put into the same shed, according to the length of time they are kept in this condition. The clutch is under the control of a set of lattice, which cause the disengagement of the clutch, and a succession of pegs causes the tappets to remain out of action according to the desired number of picks required."

The other pegs regulate, secondly, the stoppage of the take-up to give a better defined rib; and thirdly to stop the chain itself when necessary. The chain only

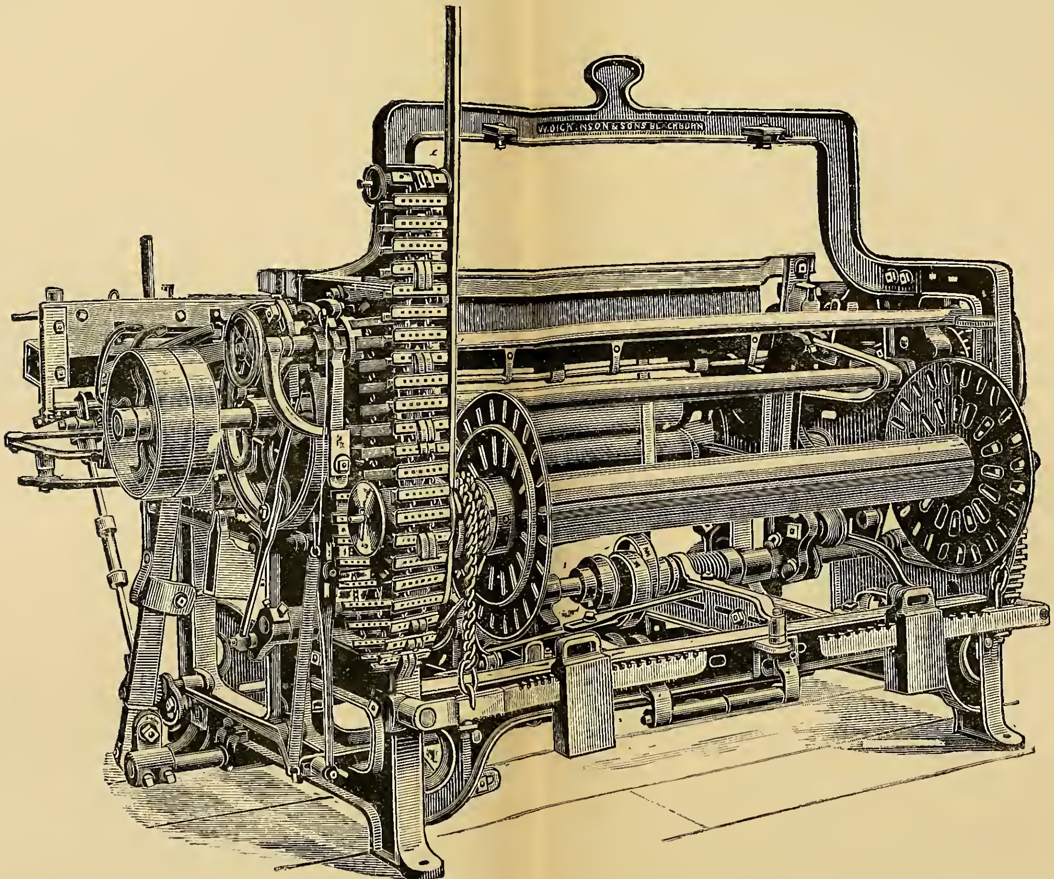


FIG. 61.—HANDKERCHIEF LOOM.

To face pp. 116 *and* 117.

represents the picks in the heading, and is stopped during the plain weaving of the body. It is started again by an ingenious measuring motion, which by a contrivance of levers starts the chain one pick, after which the catch put out of gear by peg three continues the motion. The makers claim for this motion a high rate of speed, and a low first cost of apparatus.

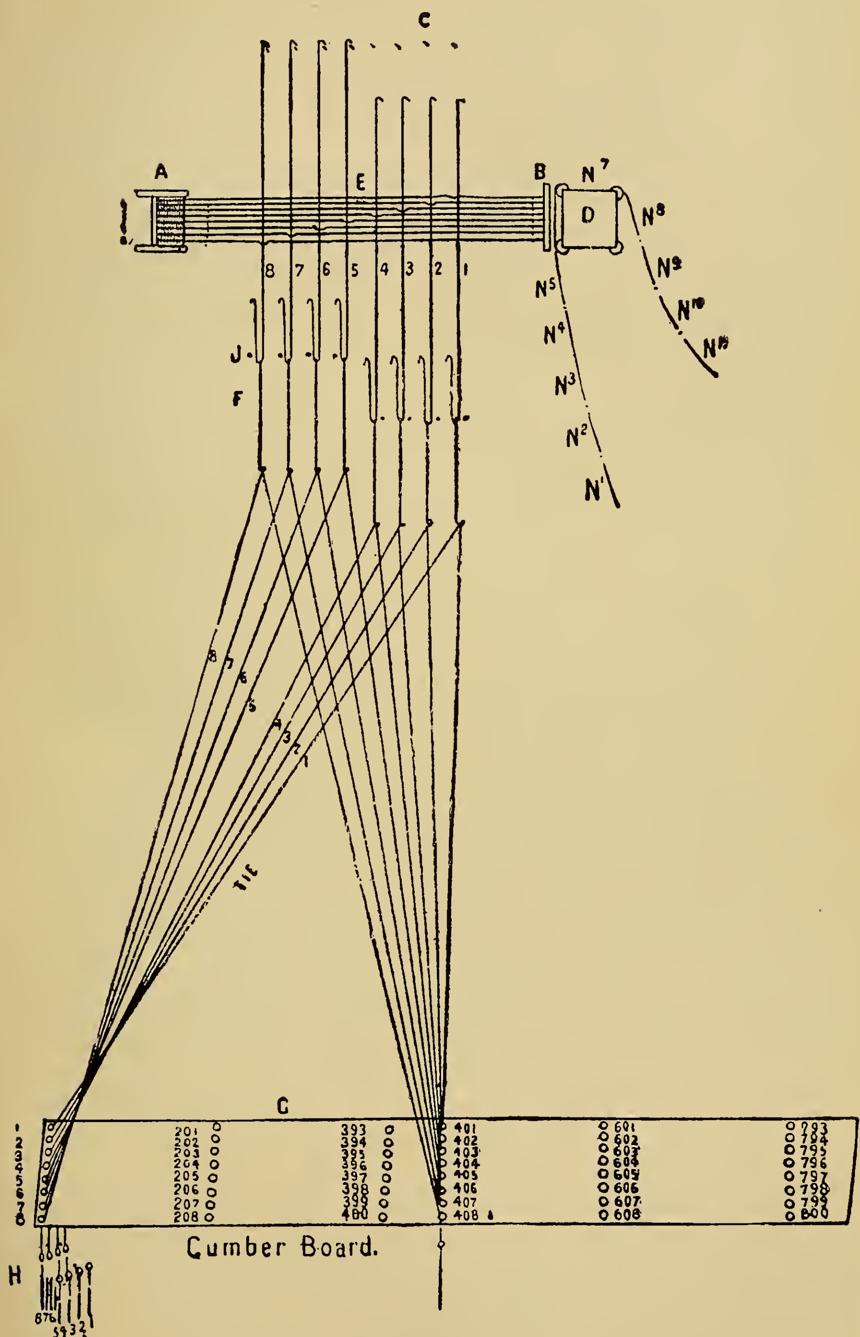
CHAPTER VII.

FANCY WEAVING BY THE JACQUARD, ITS CONSTRUCTION, CARD CUTTING, WOVEN PILE CLOTHS.

THE jacquard machine for shedding is employed in the production of some of the most complicated cotton fabrics that are woven. In its primary principle it is very simple, strangely so when we reflect on its importance in the manufacturing industry, and that by it only are we enabled to make so very ornamental cloths of great extent and beauty. Originally a French invention, the contrivance of Joseph Marie Jacquard, of Lyons, it was introduced into England in the early part of this century and adopted by the silk manufacturers. Its manufacture was early taken up by Lancashire firms, and we find now that in improved forms it is in extensive practical use in the cotton trade at the fancy weaving establishments of Bolton, Ashton, Preston, Glasgow, and other towns.

The Jacquard Machine.

The advantage of this motion is in its enormous capacity or scope of varied working of the ends. When we are aware of the existence of 1200 hook jacquards, the capacity of which is equal to that of 30 dobbies of 40 jacks each, or giving 600 times as many different workings of the ends as a plain tappet, we immediately recognise its value. It is a machine for automatically selecting out of may be thousands of threads the end or ends required to give a desired effect in the cloth. A representation of its simplest form is shown in Fig. 62.


C
A
E
B
D
N7
N8
N9
N10
N11
N5
N4
N3
N2
N1
8 7 6 5 4 3 2 1
J
F
tie
G
Cumber Board.
H

Taking a 400 hook machine, the commonest size used for cotton weaving, we find a row of 8 needles or lances E of thin wire, arranged horizontally; at the left hand we see each of these attached to a spring in the spring box A, the other end projecting about $\frac{3}{8}$-inch through a needle board B. Each lance regulates a vertical wire hooked top and bottom, and shown with each upper hook standing over its respective griffe or knife C. These griffes, eight in number, are lifted simultaneously through being connected together at the ends. The lower end of the hook rests on a wire grid J, slotted so as to allow the lower end of the hooks —to which are attached the neck cords F—to pass through. A bottom board below the bend is used for those machines which have no wire grid. To these neck cords is attached the harness—*i.e.*, linen threads or leashes, some seven feet in length, carrying a brass mail-eye H, through which the end of warp is drawn. Just above the mail-eye the harness passes through a cumber board C, for the purpose of keeping in proper order and regulating the number of leashes per inch. At the bottom of each leash is fixed a metal weight, called a lingo, intended to pull the leash down after having been raised to form the shed.

The method of raising the ends is as follows:—A square cylinder is placed at D, and makes a quarter of a revolution at each pick. This cylinder carries a set of cards (N^1, N^2, N^3), sheets of cardboard perforated in places. Supposing a 400 (408) machine is referred to, each card has space for 408 perforations, the holes corresponding in position with the ends of the 408 needles projecting through the needle board. A hole indicates a lift.

The Cards.

The cards are only perforated by groups of holes distributed incidentally, and where no perforation is made the needles at that point are pushed back $\frac{3}{8}$-inch by the cylinder. This is sufficient to remove the tops of the corresponding hooks attached to these needles from their

position over the griffe; thus, when this knife or griffe is lifted it does not actuate these hooks, but only those which were not pushed back by the cylinder and card. Suppose, for instance, one hook out of four had to be lifted, then 102 perforations would be made in the card, and 306 hooks would thus be pressed back, whilst 102 only would be lifted. The holes in these cards can be cut in any order, and as one card acts for one pick only, it is easy to realise the extent of the patterns which may be made; a cloth, for example, requiring 200 picks to the round, all of which may be different in the order or number of ends lifted, would require a set of 200 cards.

In what is called a 400 machine, 408 hooks are used, the needles being arranged in 51 rows of 8 each; one row only is shown in Fig. 62, thus the others are arranged at the back of the one shown and in line with it.

A 100 machine is in rows of 4.				
A 200 (204) machine is in rows of				4 or 8.
A 300 (304)	,,	,,	,,	6, 8 or 12.
A 600 (612)	,,	,,	,,	12.
An 800 (816)	,,	,,	,,	8 (usually 2/400's).
A 1200 (1224)	,,	,,	,,	12 (usually 2/600's).

The knives are placed on the slant so that their edge more readily catches the hook in lifting, while their under side presses the hooks out of the way when dropping.

To place 408 hooks in one row is of course out of the question, and for compactness they are placed in 51 upright rows of 8's; this advantage is more apparent in 1800 hook machines—the largest made.

The machine is fixed to a gantree above the loom *(Frontispiece)*, and in a single-action jacquard motion, such as has just been described, the knife is raised by a lever over the machine, worked by an upright rod driven by an eccentric or crank on the crank-shaft, so as to give one lift for every pick. The cylinder is suspended to a batten swinging from the top, and also worked by connection with the crank-shaft. The movement of the cylinder is to and fro; as it is moving from the needle board one corner is caught by a latch and the cylinder partially

revolves, bringing another card to face the needles, against which it is then pressed. The batten type is preferable to the sliding cylinder, which is only used in sheds where the building renders the sliding cylinder more applicable. The frame work of the batten is more solid and strong.

Single and Double Lift.

In the single-lift jacquard, the knife has to lift as often as the loom picks, and should a hook require to be raised several picks in succession, it has to be dropped between each pick and raised again. These defects are obliterated in the double-action jacquard. The machine, Fig. 64, has two hooks to each needle, they being connected at the bottom to one neck cord. Two sets of knives are used, one lifting when the loom picks from the right-hand side, the other when picking from the left, thus reducing the speed of the knife one-half; whilst as the hooks for one pick are being used, the other knife can be preparing for the next shed, and when lifting, keep up any leash several picks in succession, thus saving time, and so enabling the production to be increased. The Fig. 64 shows a double-action machine with a single cylinder, 400 hooks and swing batten, giving at least 50 picks per minute greater speed than a single lift with less vibration and strain.

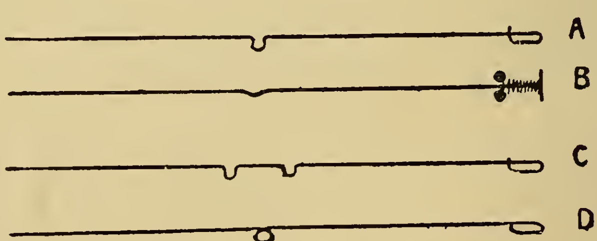


FIG. 63.

Fig. 63 shows the different shapes of jacquard needles, A being the ordinary one in plan, B another view of the

same, C the double-action one, and D another style of single-action needle.

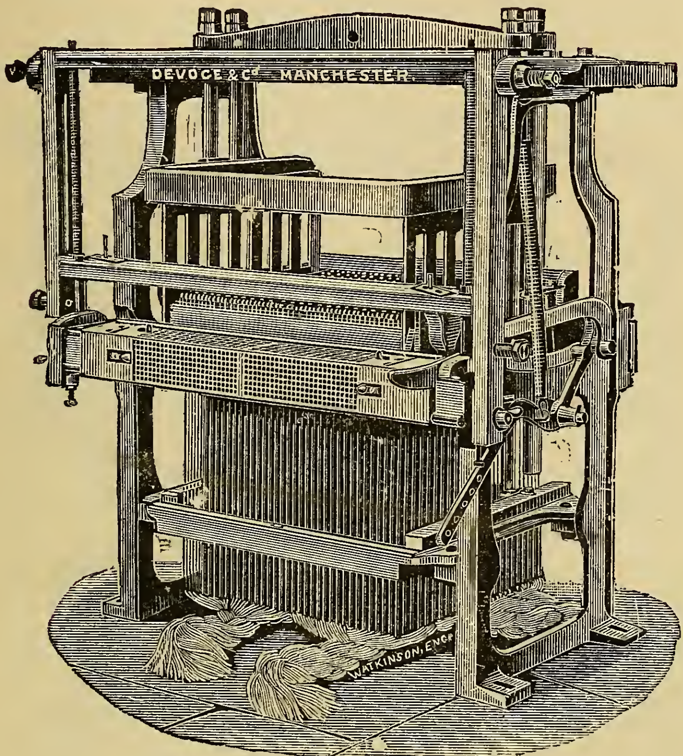


FIG. 64.

DOUBLE-ACTION JACQUARD, SINGLE CYLINDER.

The speed may still further be increased by having a double-action machine with double cylinders and two sets of needles and hooks (see Fig. 65).

In this system two sets of cards are employed, all the odd picks on one cylinder and the even ones on the other—thus, the cylinders only revolve at half the speed, causing less vibration and giving an increase of 20 picks per minute. If requisite, this machine can also be arranged as a compound or cross-border machine, carrying two sets of cards of different patterns, only one set in use

at once, while, by pulling a handle, the other set can be actuated instead, so as to weave an entirely different pattern in the cloth—*e.g.*, in the heading of a table-cloth, shawl, or handkerchief.

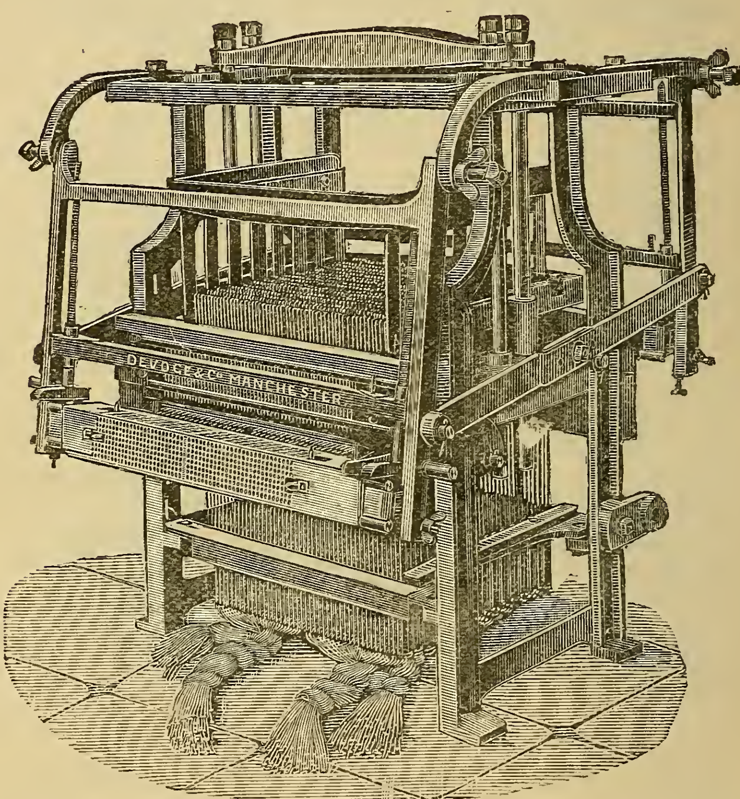


FIG. 65.

DOUBLE-ACTION JACQUARD, DOUBLE CYLINDER.

TIES.

There are two arrangements of the machine—the London arrangement being best, in which case the cards and card race are at the loom side and in better view. Fig. 62 shows this system. There is, however, more

strain on the harness, as the short rows of hooks are at right angles to the short rows in the cumber board, thus:—

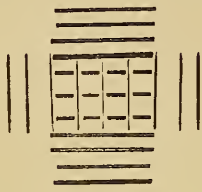


FIG. 66.

In the Norwich arrangement, the machine is placed so that the cards come over the head of the weaver or over the beam, and the short rows of 8 in the hooks correspond with the short rows of 8 in the cumber board, and thus the harness is kept straight.

The cumber board is a frame containing "slips"—pieces of wood with holes bored in rows; in a 400 machine, rows of 8; in a 600, rows of 12. Through these the leashes are passed, and the warp ends almost always drawn in straight draft through the mail eyes. Jacquard patterns are generally varied by the lifting only, and the sole variation corresponding to the draft in stave work is the tie-up. There are three ties—

1. *Straight.*—In this each hook has one end only attached to it, and the tie is as under. The rectangle represents the needle board; the dots, the needles; and the numbers, the end to which the hook on the needle is attached.

401·	17·	9·	·1
402·	·	10·	·2
403·	·	11·	·3
404·	·	·	·4
405·	22·	·	·5
406·	·	·	·6
407·	·	·	·7
408·	24·	16·	·8

FIG. 67.

Nos. 1 to 8 will be in the first row of the cumber board to the left-hand side of the cloth.

2. *A Lay-over Tie* (the commonest).—It is the same thing, except that two or more patterns are woven in the width of the cloth, say three. Then three ends would be attached to each neck cord, and in a 400 machine 1200 ends would be used. The cumber board plan would be repeated thrice. For example, a pattern on 9 hooks—

HOOKS.	4	3	2	1	9	8	7	6	5	4	3	2	1	9	8	7	6	5	4	3	2	1
ENDS.	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

FIG. 68.

Fig. 62 shows a portion of a lay-over tie, the ends attached to the first row of hooks being in the first row in the cumber board, and the pattern being completed on 400 ends; the 401's, etc., are attached to the first, etc.

3. *A Centred Tie.*—When a pattern of 815 ends is in two equal and balanced portions, the middle end of the cloth is tied to the hook at the right side, and two ends to every other hook, the pattern thus being woven on 408 hooks, *e.g.*—

HOOKS.	403	404	405	406	407	408	407	406	405	404	403
ENDS.	413	412	411	410	409	408	407	406	405	404	403

FIG. 69.

In harness building or mounting, considerable ingenuity has to be displayed in keeping the leashes in proper order, and in knotting the harness to the neck cord so as to produce a small but strong joint.

The warp is drawn through the mails after the beam has been slung at the loom.

THE SHED.

A jacquard shed presents a different appearance to a plain loom shed—the large overhead machines darkening the scene. Where the weaver is expected to mind four

looms, only about half the looms are jacquarded, and then only when the simpler styles are woven, indeed one jacquard out of four looms is considered sufficient for most cloths. In the mills where all the looms are engaged on jacquard cloths, one weaver cannot attend to four looms. Compared with plain goods, the preparation machinery for jacquard work possesses no peculiarity. The power required to drive is greater, the weaver's work generally less laborious and more intricate, the warps weave better as they are sized more lightly, and also the harness gives way to the shuttle or to any obstruction better than healds; the highest speed for medium widths is about 200 in double cylinder—double lift. It is important that no picks be missed; therefore, in starting a loom, the cards must be turned back to their proper position. This is done by reversing motion.

Card Cutting and Repeating.

The method of transferring designs to design paper is described on page 93. After the design has been finished the cards have to be cut. The first set is prepared in a piano card-cutting machine, the place where the hole has to be made being read from the design—thus, if for the first pick the 1, 2, 9, 15, 18, 30, 31, 32, 33 and 40 hooks have to be raised, holes would be made as under, looking at the face of the card or the side which is in contact with the needles—

	1	9	.	.	33	.	
	2	.	18	.	.	.	
	.	.	.	.	.	.	
Numbers indicating holes.	.	.	.	.	.	.	The left-hand side here is the right on the machine.
	.	.	.	.	.	.	
	.	.	.	30	.	.	
	.	15	.	31	.	.	
	.	.	.	32	40	.	

The piano card-cutting machine is shown at Fig. 70.

The punches which make the holes in the card are operated by the attendant's feet actuating a treadle, but the punches are regulated by his finger pressing certain

keys and thus causing only those punches to be locked where holes are required. There are only sufficient keys to cut the short row of 8 at one stroke.

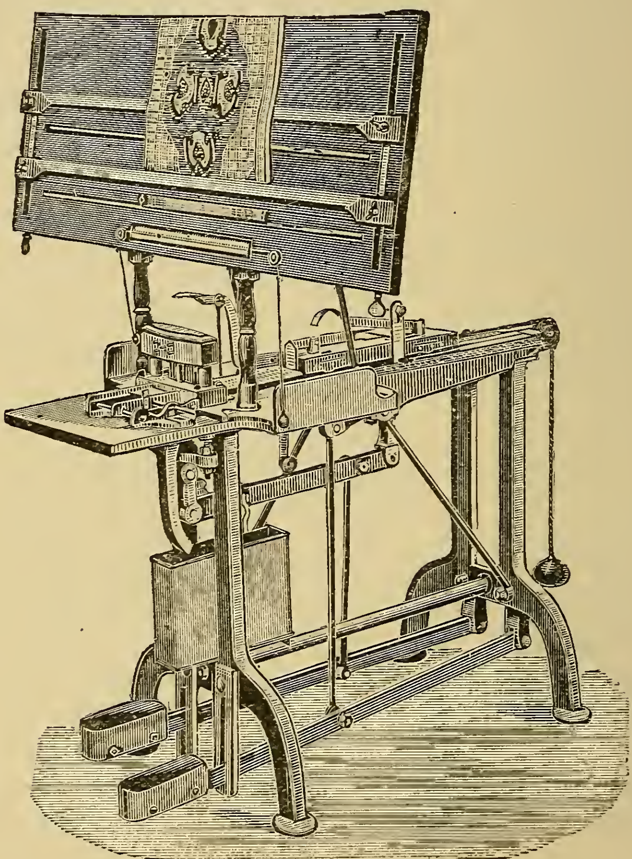


FIG. 70.

After one set of cards has been cut from the design, any number of sets can be made from it on a repeating machine. The original set is placed on a jacquard cylinder and actuates the needles in the ordinary manner, excepting that the hooks are pushed on the knives by the blanks in the card. These hooks are attached to punches, and at each stroke of the knives a card is cut, a duplicate of the original one then on the lantern face. The holes are cut

by the punches which are not lifted and which are locked by wedges at each stroke. On this machine cards can be repeated at the rate of 40 per minute.

Casting Out.

In lay-over patterns a number of ends are tied to one hook, and if the pattern contains as many ends as there are hooks, or some factor of the number, it is easy to calculate how many shall be tied. In a warp of 1600 ends in 400 machine, and 400 ends in the pattern, four would be tied to each hook. With 100 ends in the pattern there would be 16 ends similar, which, however, would be divided between the four patterns representing the capacity of the machine, still giving four ends to a hook. We are supposing that any hooks over 400, 600, 800, etc., are use for selvage. However, suppose there are 64 ends in the pattern, the machine will weave six patterns and have 16 hooks to spare, which would be cast out—

$$6 \times 64 = 384 + 16 = 400.$$

One row of 8 would be cast in the middle and another at the end. The 1600 ends, neglecting selvages, will give 25 complete patterns of 64 ends each in the width of the cloth; this will give four ends and four patterns to each hook to five sets, and five patterns or five ends to a hook, in the sixth set.

Jacquard Goods.

Regular cloths vary from small patterns on 20 ends and 20 picks to others with 2000 ends and picks in a round, while for exceptional cases these limits are far exceeded. A feature of many jacquard cloths is a figure more or less fanciful on a ground which may be plain, twill, satin or oatmeal weave. Spots and brilliants are examples of this style.

Damasks are extensively made. The true damask weave consists of a design of large extent, woven, we will suppose, with weft predominating in the figure, which may be bound by satin or twill weave. The ground is also in

similar weave, but with warp predominating. Thus the cloth is firmly bound at all parts of its surface and is reversible.

The damasks woven in cotton do not always fulfil these conditions, but are in sufficiently similar style to warrant their being classified together. Frequently they are made in light goods of about 60 ends and picks per inch for export to China and other countries, or heavier both in yarn and pick with a finer reed for the home trade. These goods are of great variety of pattern and are generally finished before use, or, as in the case of furniture and curtain damasks, dyed.

Dimity is a cloth of smaller pretensions with regard to figure, which is arranged in stripe form. The cloth is firmly bound, and the figure somewhat raised, which gives it an embossed effect.

Brocades are jacquard cloths of fine yarns, the pattern arranged in weft spot on plain ground, or narrow stripes of spotted figures, which, when well finished, have a charming effect. The brocade is not limited to the longitudinal stripe or figure, but may be arranged as a brocade check, while the ground cloth in either case may be of plain weave. A good effect is also produced by arranging this style in diamond figures by introducing honeycomb diagonally.

Figured canvas gives a pleasing effect when dyed. The figure is woven in plain cloth, and the work between the figures shows the end cramped together alternately with open spaces, so as to give an open effect, on which the figures show to advantage.

Figured gauze cloths are woven by the jacquard. This industry is carried on to a large extent in the cotton districts of Scotland. The harness of the machine is arranged with doup leashes passing under the plain ends to the crossing thread, which is drawn through a mail corresponding to the back stave in heald gauze working. The gauze figures are shown on a plain ground and present the pattern in open work, caused by the peculiar intertwining of the warp ends indicated in a previous chapter.

Counterpanes.

The jacquard is largely used in the counterpane and quilt industry, centred in Bolton. The Marseilles and toilet quilts, with which may be associated the well-known toilet cloths, are on the double-cloth principle—a good face of plain weave in fine yarns being embossed, as it were, by a thick soft weft being woven underneath and attached to the cloth by additional warp threads. This backing weft sometimes floats outside the cloth, sometimes is bound inside just below the plain face, and at other parts the whole of the yarn is firmly united. Where the backing is brought inside, the top cloth is raised up; whilst at those places where all the ends are woven together a depression is caused. Large embossed figures may thus be shown on the cloth, although it appears to have an unbroken surface. A coarser quality is made, where both face and back wefts are coarse and from the same cop.

Perched quiltings are in this style, but the figures are small, diamond-shaped, and regular.

The honeycomb quilt, as its name implies, is a cloth with the figures on its surface formed by raised ridges both warp and weft way. This is generally woven in bleached knitting cottons, two or three-fold; and as with this weave others may be combined, and stripes of coloured worsted inserted, great scope is given to the designer.

A Grecian quilt is woven in bleached knitting cottons, and yet the coarse threads give a smooth glossy surface in consequence of the weave being on the damask principle —*i.e.*, the figure may be formed in a weft satin while the ground is a warp satin.

The Alhambra quilts are figured in various designs and woven with vari-coloured yarns.

Woven Pile Cloths.

A class of cloth has now to be referred to which does not usually come under the scope of jacquard work. The velveteen classes of cloth have been described, in which

the pile is cut after the cloth leaves the loom. There is one style of pile cloth, occasionally woven in cotton, in which the pile is cut whilst in the loom. Two beams are used, one carrying the warp for the pile, and the other the warp for the ground cloth in which the pile is bound. A couple of picks of weft are inserted, and then a wire about one-twentieth of an inch thick, and of varying depth, consequent on the length of pile required; when this wire is beaten up to the fall of the cloth, the warp is allowed to be slackened, and it thus forms a loop on the cloth face. Two more picks are inserted and another wire, which is continued. The weaver sometimes draws the wire out—leaving looped cloth—or cuts it out along a groove, in which case a nap is caused on the cloth face. The best system, however, is to employ special looms for the purpose, which not only insert the wires in the proper shed, but also draw them out, and, as they bear a sharp knife at the farther end, cut the loops to form pile in doing so.

Another pile fabric of cotton or linen which has attracted greater attention during the last few years is the Turkish or Terry towel. This is woven with two beams, one for the loop pile, and the other carrying the ground warp, which is always kept tight. After two picks have been inserted and tightly beaten up, the reed is allowed to fly loose by a peculiar arrangement, and, both warps being kept tight, two picks are put in without beating up. Then the reed is fastened, the loop warp slackened, and on the next pick being beaten up, the two previous ones are also driven home, and with them the loop warp which stood between the fell and the two neglected picks, thus forming loops on both sides of the cloth.

This weave is not confined to the making of fabrics with an unbroken pile surface, but is adopted in stripes for bath towels and wraps, in checks and even figures for quilts, combined with colour in other effects, and also woven alternately in some special cloth with entirely different patterns. The headings also for the towels are of a firmer weave, and afford great scope for ornamentation.

CHAPTER VIII.

DROP-BOX LOOMS, STRIPES, CHECKS, AND SPOTTING.

IN certain classes of cotton fabrics stripes are a leading feature of the cloth, and are made either in colour or in different counts of yarn, or reed or pick; stripes may run length-way of the face as in dhooties, sarongs, some shirtings, regettas, tape muslin, ticks, and many other cloths, and in these cases the effect is produced simply by warping and reeding the ends in the required order, often by varying the number of ends in different dents.

STRIPES

May run transversely, and are then formed by coloured or vari-counted yarns, or a series of spots in colour may be shown on the face of the cloth, a stripe of extra weft being shown at the back of the cloth and brought through to the face as required. In these cases some system of manipulating extra shuttles carrying the different wefts must be adopted.

CHECKS.

The third class with which this chapter more especially deals is the checked cloth—ginghams, Oxford and Harvard shirtings, tape checks, satin checks, etc. These are all formed by combining warp stripes with weft stripes of corresponding colour and extent, thus forming squares of colour on the fabric. These patterns may be formed in endless variety of colour, weave, or length.

In ginghams, the colours used are often four or five in number—say 20 pink ends, 2 black, 6 white, 2 black, 6 white, 6 black, 6 white, 2 black, 6 white, 2 black = 58 ends in the warp pattern, while the picks of weft are in the same colours, number, and order. In the larger patterns the number of ends and picks may get into the hundreds. Fine counts are often used.

In shirtings of heavy material for the home cotton and union material trade, smaller patterns are commoner, as they are also in all the "zephyr" class of goods—such, for instance, as shirting, warping 12 white 24's, 2 red 20's, 12 white 24's, 2 blue 20's; weft same; weave, 4-end cashmere twill.

In white yarns, satin checks may be made with satin stripes on a plain ground, the satin ends being "cramped" in the reed, and the picks being inserted in other yarn of special spinning.

Tape checks are similar, excepting that the weave is plain all through. These one-colour checks must not be confused with the crossovers and the satin or other checks formed by the same weft, but heavier in pick at places.

Handkerchiefs in colour have the appearance of a large check, but when the coloured headings are far removed it is advisable to change shuttles by hand, as the chain for the drop box would be too long. Some check looms, however, carry contrivances for stopping the motion of the chain when the body of the handkerchief, shawl, towel, etc., is being woven, this being a very suitable system. In case of changing by hand a measuring motion is attached to the take-up roller to stop the loom at the place for heading.

The Drop-box Loom.

For changing the shuttle a drop-box loom is generally employed. In a double drop-box machine six boxes may be used at each side of the loom, any one of which may be brought into action, giving a scope of eleven colours of weft. The single drop box is, however, more usually

employed, with four or six boxes at one side of the loom, only giving four or six colours, but not allowing less than two picks of the same colour to be put in. To insert single picks of colour a double-box loom is used, and possesses a special pick-and-pick arrangement (uncommon in the cotton trade) to admit of its picking twice consecutively from either side of the loom. The number of boxes just mentioned is seldom met with in the cotton trade, three and four boxes being the usual sizes. The single four-shuttle drop box carries a frame at one end of the slay in which the boxes or shelves rise or fall. These boxes contain the shuttles, and by suitable regulating motions the boxes may be shifted so as to bring any one shuttle level with the shuttle race and in front of the picker. The spindle is duplicated, and the couple is placed in front of the box, not above, as in a plain over-pick loom. The picker is broad and is without nib, fixed in a horizontal position, so as to act on any one of the shuttles which may be placed before it. The principal drop-box regulating motions are Diggle's chain and Wright Shaw's motion.

DIGGLE'S CHAIN MOTION.

Diggle's chain is noted for short patterns, is simple in construction, and sure in its action. Attached to the loom top is a star wheel A and barrel B revolving on a stud. The barrel carries a chain C, of different sizes of links united by pins; the star wheel receives its motion through a train of wheels from the crank-shaft, of which D and E are connections. The links of the chain support a lever F, connected with another lever G at the loom side supporting the drop boxes. For a four-shuttle box the links are of four heights, the deepest raising the boxes to the highest point, while the lowest link supports the levers so that the boxes are at the bottom, with the top shuttle level with the shuttle race. The chain is arranged so that a sufficient number of links of the same height are placed together where several picks of the same colour are required. The shapes of the links are varied to adapt the lifts from or sinking to different boxes—thus, for a four-

box loom twenty different shapes of links may be used to give lifts or depressions from any box of the four to any other; their arrangement in chain depends on the before-mentioned principle. A plate of links is shown at Fig. 72. They will be seen to be of four different heights. A

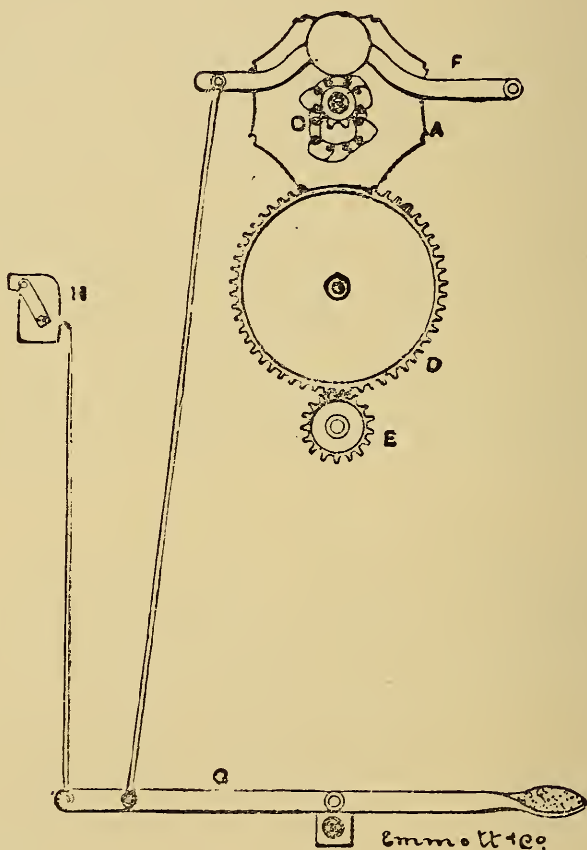


FIG. 71.

44-inch loom of this make may run 150 picks per minute. The change of shuttle is made immediately the shuttle enters the box. We are not able to change the shuttle at less intervals than two picks, but can do so at greater intervals—say, for example, once in four picks.

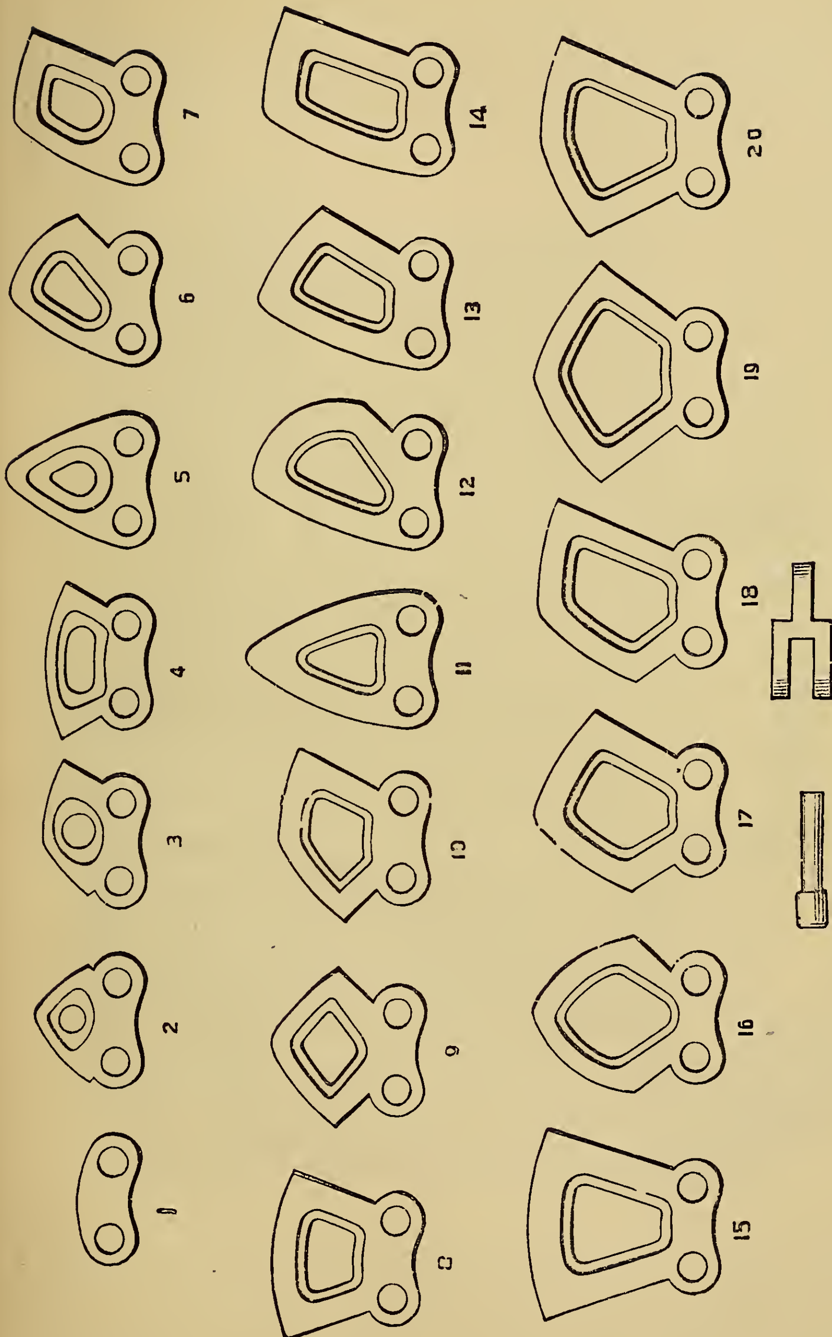


FIG. 72.

WRIGHT SHAW MOTION.

The motion called, after its inventor, the Wright Shaw motion is perhaps more suitable to cotton goods. Indeed, in Manchester, near to which city it was

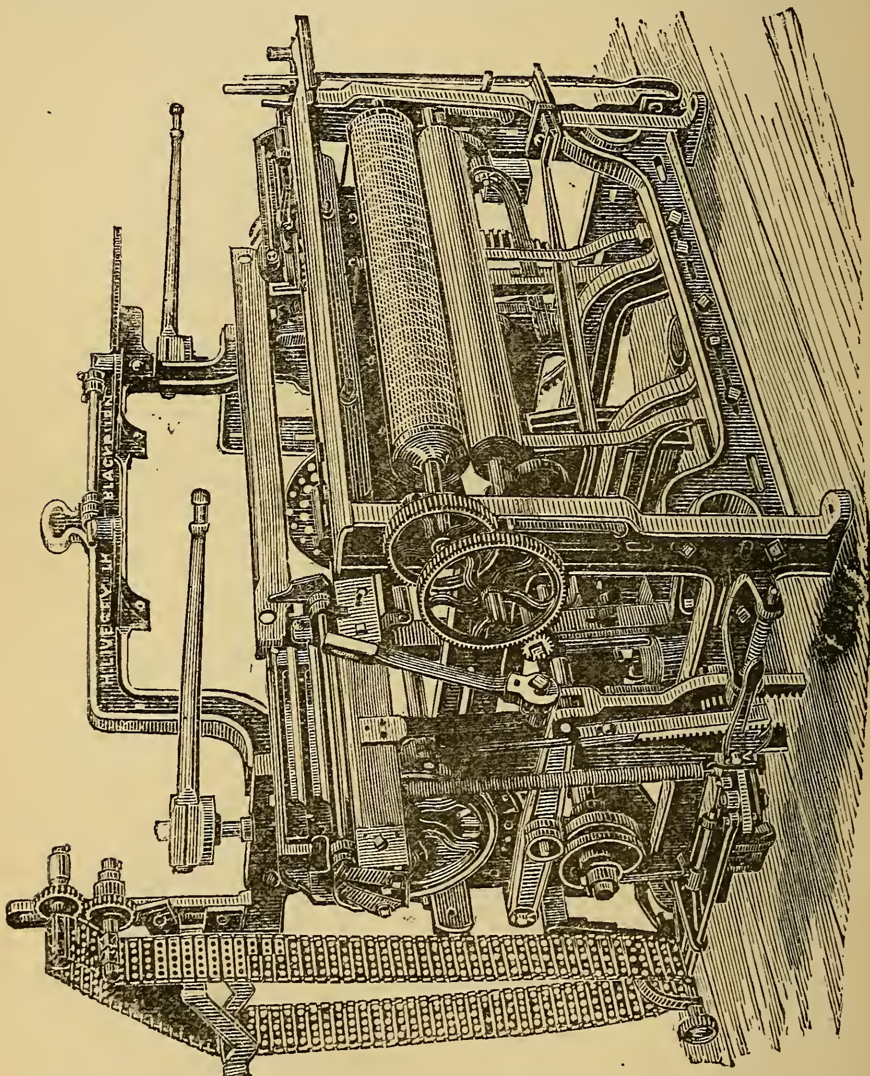
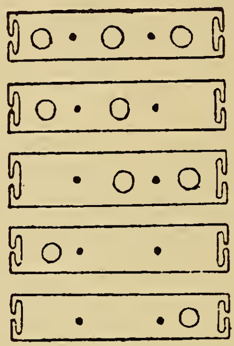


FIG. 73.

invented and is manufactured, it finds much favour in the check trade. A greatly improved motion has been recently introduced by Mr. Wright Shaw, but as the older form is in commoner use, we will refer to the latter.

Fig. 73 shows a sketch of this machine, in which the parts will be clearly seen. It is the make of Messrs. Henry Livesey, Limited, of Blackburn, but is on the Wright Shaw principle improved. The shuttle box is supported and moved by a rack and pinion; this pinion shaft is actuated by a forked rack supported on a pivot at the end of a lever, so as to gear with either side of another wheel on the pinion shaft. The lever is driven by a cam, and raises and lowers the fork. The pattern chain consists of iron plates which are thin and narrow, thus enabling a longer pattern to be obtained than is possible by the previously described motion. These plates are linked together by elastic bands, and each contains two peg holes, and also one, two, or three larger holes to correspond with the points of the three-pattern chain needles. The pattern chain passes round a square block perforated to correspond with the needles, and driven at the speed of a quarter of a revolution for each two picks. The pegs on it carry the pattern plates round with the block. The needles are arranged horizontally, points facing pattern block. The outer needles regulate whether the right or left leg of the fork shall be in contact with the wheel on pinion shaft, to determine whether the reciprocation shall be upwards or downwards. A hole in either one side or the other of the plate regulates this; should both sides be perforated, the fork remains in its previous position. The fork is raised and depressed by a lever, actuated by one of two cams—one to move the boxes one shelf, and the other to skip a shelf, thus moving two boxes. These cams are changeable, and operate on one end of the lever, while the fork is suspended to the other end. The central needle decides which shall be in action, as it carries a projection which, when pushed back, thrusts the larger sweep cam into action. It is easy, therefore, to understand the action of these cards; three holes give no movement; two holes, with a blank at one side, put the fork into gear with the corresponding side of the pinion wheel; and in the case of two blanks, the one in the centre puts two-box stroke in action, and the side blank puts the fork in gear at one side. One blank at

the right side causes a rise, or, at the left side, a fall. The five forms of plate are :—



No change.

Rise one.

Fall one.

Rise two.

Fall two.

Rising one means that the box is risen to the next shelf; rising two is risen to the next shelf but one, skipping one. This style of drop box can be driven at the speed of 170 picks per minute. Generally, a weaver attends to three of these looms, and an overlooker to from 50 to 60. For the check shirting trade looms to weave from 30-inch to 37-inch cloth are used.

OTHER MOTIONS.

An ingenious drop-box motion is manufactured by a Burnley firm, by which the weight of supporting the boxes, etc., is altogether removed from the pattern chain, which is consequently made of less cumbrous construction. Other firms claim decided advantages in respect of a greater skip than either Diggle's or Wright Shaw's motions—*e.g.*, from the first to the sixth box. Skips of this extent are obtained principally by using several eccentric cams. One of these may lift a single box, a second may raise the boxes two spaces, and their effect in combination is a lift of three shuttles, and so on for greater effects.

CIRCULAR BOXES.

Circular boxes are seldom used for cotton goods. In this arrangement the shuttles are fixed in grooves formed in a block revolving at the slay end, and drawn round in

either direction by hooks, one being placed at each side of the revolving barrel. The movement of the hooks is regulated by a pattern chain. The speed is about the same as a Wright Shaw motion.

GENERAL.

Any of these types of boxes may be used with the over-pick, and either with tappets, dobby, or jacquard shedding. Attempts have recently been made to apply the drop-box principle to a system of replenishing the loom with three or four cops of weft without a stoppage, by having them previously placed in the shelves and lowered on the breakage or running-off of the previous weft.

Coloured Spots.

Additional colour is introduced into cotton fabrics in spots and figures after the manner of embroidery, by using circle swivels or lappets. If a series of small spots in colour are required to be made, by using a drop-box loom with a jacquard or dobby the object is easily attained, but it necessitates the cutting away of much of the coloured yarn which has been picked across the cloth, and only a portion of which is required for the figure. Now, by using extra twist or weft, and only interweaving as much as is required for the figure alone, much waste can be prevented, and a firmer spot obtained. Take, for example, the spotted muslin so frequently used for window curtains; each figure only consists of a few inches of coarse yarn so loosely passed through the ground cloth, and apparently so entirely independent of the other spots, that a tyro can form no other explanation of their appearance there than that they have been sewn on.

Circle Weaving.

Circle weaving has been used in these cases. In addition to the ground weft, which is carried across the cloth in the ordinary shuttle, there is a frame above the

shed of the warp carrying several circular, or rather horse-shoe-shaped attachments with a small bobbin of weft pivoted at the upper part (farthest from the opening in the ring). These rings are driven round by gearing with a rack. When the figure has to be formed by the weft passing round, say 20 ends, these are raised above the level of the top of the ordinary shed, inside the ring, which then makes one complete revolution, and the ends are depressed. Maybe a plain pick or two is then inserted, and afterwards more spotting, until the desired figure is embroidered on the muslin, when plain weaving is resumed for a few inches.

Lappets.

In lappet weaving, extra bobbins of warp are placed below the loom, and the ends from them carried to a set of upright needles, which slide in a groove immediately in front of the end, a false reed being arranged for the guidance of the shuttle. The needles are regulated by a cam, and, with their point projecting, raise the thread into the shed, so that it may be bound into the cloth by the weft; after which the needles are removed the distance of a few threads, and again raise the coloured end, so that it may be bound into the cloth. The cam causes the needles to be slid to and fro in this manner until a figure is formed as desired. By this latter method the colour in the figure largely predominates on one side of the cloth, that which is the under side in the loom. The upper side merely shows the outline of the figure where the thread has passed through to be bound. In the circle swivel figures the weft usually shows equally on both sides.

CHAPTER IX.

MILL CALCULATIONS—YARN COUNTS, REEDS, HEALDS, COST OF CLOTH, WARPING AND SIZING LENGTHS, WAGES, SPEEDS, ENGINES.

IT is desirable that the calculations connected with cotton manufacturing in all its bearings be treated in a separate chapter. This is not only necessary from their number, but from their great variety and difficulty of classification under different chapter headings, inasmuch as many are applicable to more than one process.

Yarn Calculations.

The fineness of cotton yarn is indicated by the counts (otherwise numbers or grist). The counts refer to the number of hanks in a pound (avoirdupois). The cotton hank is always 840 yards; and, therefore, if we speak of 10's, we refer to yarn of which 10 hanks or 8400 yards weigh one pound; or in referring to 36's, of that which 36 × 840 or 30,240 yards weigh one pound. This applies to either twist or weft. The cotton yarn measure is—

120 yards = 1 lea.
7 leas or 840 yards = 1 hank.

and the cotton yarn weight is peculiar, being an avoirdupois pound divided into pennyweights and ounces as in the troy weight.

24	grains	=	1	pennyweight.		
437½	grains	=	18$\frac{11}{48}$	pennyweights	=	1 ounce.
7000	grains	=	16	ounces	=	1lb.

Wrapping.

1's are taken as the standard with 840 yards in 7000 grains, and a higher count means finer yarn; then 840 yards of, say 2's, would weigh 3500 grains, or of 70's, would weigh 100 grains. If we measure a hank of yarn, and find that it weighs 100 grains, then 7000, divided by 100, gives the counts. It is inconvenient in wrapping yarn to measure 840 yards, therefore a lea of 120 yards is taken as the standard length for 1's, and also the proportionate weight = 1000 grains. Instead of taking 840 yards and 7000 grains it is usual, then, to take 120 yards and 1000 grains. A wrap reel is $1\frac{1}{2}$ yards in circumference, and, by revolving it 80 times, we can wind 120 yards from a cop placed in the machine. Suppose this lea of 120 yards weighs 25 grains, then $\frac{1000}{25}$ = 40's. Should less than a lea be taken, say 60 yards, then 500 grains must be the dividend. Generally, however, *to obtain the counts* of any yarn, 120 yards are weighed, and the weight, in grains, divided into 1000.

Having the Length and Counts given, to find the Weight.—9240 yards of 44's weft = 9240 yards ÷ 840 = 11 hanks. In the given counts 44 hanks weigh 1lb., then 11 hanks weigh $\frac{11}{44}$, or $\frac{1}{4}$ of a lb.

Counts of Silk, Worsted, Linen.—Single silk is counted same as cotton, except that in two-fold patent silk the actual wrapping is given—say, 30's/2 in silk will wrap 30's. In cotton, 2/30's would wrap 15's. The worsted hank is 560 yards. The linen "lea" is 300 yards. The French cotton standard is 1000 metres in 500 grammes—equivalent to 992·4 yards in 1lb. Thus, 1·181's in English would be 1's in French. To transfer cotton measure to any other take the cotton count, proportion it inversely to the number of yards in the hanks, say—

20's cotton equals 30's worsted,

$$\frac{20 \times 840}{560} = 30\text{'s}.$$

20's cotton equals 56's linen,

300 : 840 : : 20's : 56's.

20's cotton equals 20's silk.
20's English equals 16·93's French.

$$1·18 : 1 :: 20\text{'s} : x$$

$$x = \frac{1 \times 20}{1·181} = 16·93$$

Double Yarns (Cotton).—Two-fold yarns are numbered according to the single yarn counts—thus, 2/80's = two ends of 80's twined together, which would wrap 40's. Actually, to make the resultant count 40's, the single yarn should be finer than 80's, because the twist put in the folded yarn contracts it in length and causes the two-fold to be really coarser than would appear. However, neglecting this, suppose we twine one end of 40's and one of 20's, the counts would not be 15's, as a first glance would indicate, but 13·33. This can be proved by taking the weight of a lea of 40 = 25 grains, and of 20's = 50 grains; total, 75. 75 divided into 1000 gives the counts as $13\frac{1}{3}$. Another rule is, multiply the two counts and divide by their sum—

$$\frac{40 \times 20}{40 + 20} = \frac{800}{60} = 13\tfrac{1}{3}$$

3/300's = 100's.

3-fold yarn of 40's, 80's, and 120's would be 21·81.

A lea of 40's = 25 grains.
A lea of 80's = $12\frac{1}{2}$ "
A lea of 120's = $8\frac{1}{3}$ "

$45\frac{5}{6}$

$$\frac{1000}{45\frac{5}{6}} = 21·81$$

Or take the highest count and divide it by each of the others and by itself, then divide the total of the quotients into the highest—

$$120 \div 80 = 1\tfrac{1}{2}$$
$$120 \div 40 = 3$$
$$120 \div 120 = 1$$

$$5\tfrac{1}{2} \quad \frac{120}{5\frac{1}{2}} = 21·81$$

Testing Yarns.

In addition to wrapping warp yarn to ascertain actual counts, it is frequently tested as to strength; the lea from the reel is placed between two hooks on a testing machine, and by a wheel worm and screw the lower hook is moved downwards, increasing the tension on the yarn. By an index finger this tension is indicated on a face plate, and when the lea is broken the finger stops at the highest weight or strain that the yarn has stood. Below is a table, which will give a general idea of the comparative strength of mule twists, having, for the American cotton, the standard turns in—*i.e.*, square root of counts multiplied by $3\frac{3}{4}$.

20's	American Cotton		= 80lb.
30's	,,	,,	= 54lb.
40's	,,	,,	= 40lb.
	Egyptian	,,	= 50lb.
50's	American	,,	= 28lb.
	Egyptian	,,	= 37lb.
60's	,,	,,	= 30lb.
70's	,,	,,	= 26lb.

In yarn the diameters of the threads do not vary inversely as the counts, but inversely as the square root of the counts. Thus, 16's is not four times as thick as 64's, but twice as thick, the square roots being four and eight respectively.

Reed Counting.

Before entering into the calculations regarding the weight of cloth, it is necessary to familiarise ourselves with some method of counting the ends of warp in the cloth. On the Exchange the system adopted both for ends and pick is their number per quarter inch—*e.g.*, a 16 by 14 means 16 ends per $\frac{1}{4}$-inch, or 14 picks per quarter. The methods used in the manufactory are based on the counts of reed. Formerly many systems of reed counts prevailed, each town or district having a method peculiar to itself; thus, Blackburn counts, Preston counts

and many others were at one time adhered to in their respective districts, but have now fallen into disuse, and almost been forgotten. The Stockport counts is commonest in Lancashire, and is based on the number of dents or splits of the reed in two inches, and as cloth is generally wrought two ends on a dent, this system is often taken as the number of ends in one inch. It is in use in almost every Lancashire manufacturing district, being adopted in consequence of its simplicity and suitability for calculation purposes.

The Bolton counts is still used in some mills in that town and also in Bury and some few other districts. It is based on the number of beers in $24\frac{1}{4}$ inches—a beer comprising 20 dents. A Stockport 40's reed would have 485 dents on $24\frac{1}{4}$ inches, or $24\frac{1}{4}$ beers Bolton. A Bolton $24\frac{1}{4}$ reed is then equal to a Stockport 40's. To find the number of splits per inch in a reed having Bolton counts given, multiply those counts by ·8249, or *vice versâ*. This rule shows the number of dents and decimal parts; 8·245 is more often taken, but it gives the number with less exactitude. The fraction is only taken to two places of decimals, showing thus the 100th parts of dents—*e.g.*, a 30° Bolton has $24\frac{74}{100}$ splits per inch ($8{\cdot}249 \times 30 = 24{\cdot}747$). To convert Stockport into Bolton counts multiply by ·60625. To convert Bolton into Stockport multiply by 1·6495. This rule gives the number of ends per inch in Bolton counts, supposing the cloth to be wrought two ends in a dent. The Scotch systems are to take the number of dents or splits in the old Scotch ell, 37 inches, or by the number of porters on the same length. The Scotch porter is equal to the Lancashire beer—20 splits. In the first system, the splits per ell are expressed in hundreds—thus, 17^{00} indicates 1700 splits on 37 inches, almost equal to a 92 reed, Stockport; or a 46 on the Scotch inch scale, which is the number of splits in one inch, and corresponding to the old Radcliffe and Pilkington method in Lancashire.

By the porter system, a 40-porter reed would give 40×20 dents = 800 on 37 inches, equal to a 43 reed, Stockport. In Scotland (as in Lancashire) the old

complicated systems show a tendency to give way in favour of the simpler systems of counting the dents or ends in one inch.

In the reed table given below, the first row of figures shows the proportion which these reeds bear to one another, and the lower rows indicate the fineness of the different systems for 33 and 40 splits per inch respectively —the calculation results being given, which same might not frequently appear in practice—

The Inch Scale. Dents per Inch.	Stockport Dents on 2 Inches.	Bolton Beers on 24¼ Inches.	Scotch. 100 ends on 37 Inches.	Scotch Porter. Porters on 37 Inches.
1	2	1·2125	0·37	1·85
33	66	40·	12·20	61
40	80	48·5	14·80	74

HEALDS.

In Stockport counts four healds are considered as a set, and having one thread through each eye are dubbed of similar counts to the reed—*e.g.*, a 60's set of healds has 15 stitches per inch in each set, equalling 60 ends per inch in the reed, which is a 60's reed, Stockport.

In spaced healds some are knitted finer than others and consequently numbered differently. In this point draft:—

				5				5			
			4		4		4		4		
		3				3				3	
	2										2
1											

twelve ends are drawn on five healds, one end on the 1st heald, two on the 2nd, three on the 3rd, four on the 4th, and two on the 5th. Four different degrees of fineness are required in the five heald staves, and the above draft is given to the knitter with instructions for so many patterns to the inch. Say five patterns per inch: 5 × 12 would give a 60 reed, and the number of stitches per inch would be respectively 5, 10, 15, 20 and 10—the front one being equal to a Stockport 20's, for if there were four similar to it in a set, the number of ends would be 20.

Similarly the second stave equals a Stockport 40's, the third 60's, the fourth 80's, and the fifth same as the second, a 40's. To prove this, the requisite set of five staves might be obtained by taking one stave out of a plain 20's set, two staves of a plain 40's, one stave from a 60's, and one from an 80's set.

Weight of a Piece.

In calculating the weight of a piece, the warp weight is obtained from the number of ends, based upon the width in the reed. This is multiplied by the sizing length and brought into hanks, from which the weight can be obtained by dividing by the counts. The weft is calculated from the picks to the inch, the reed width, and the actual length of piece. Example—A piece has to be made full dimensions, 36 inches wide, 36 yards long, 16 square ($\frac{1}{4}$ inch)—*i.e.*, 64 ends per inch and 64 picks; yarns 30's/36's, the first number being the warp, sized 25 per cent. In the reed it would stand 38 inches, about six per cent. being allowed for contraction. Of course, if the yarn were coarser, the pick heavier, and the reed finer, more than this would be allowed. Supposing that a 60's reed (Stockport) is used, the number of ends would be $38 \times 60 = 2280$; the length of warp, say 38 yards, allowing six per cent.—then

$$\frac{2280 \times 38}{840} = 103\tfrac{1}{7} \text{ hanks,}$$

Divided by 30's gives 3lb. 7oz.

Weft.—The weft, $37\frac{1}{2}$ inches wide, 64 picks; length of piece, 36 yards.

$$\frac{37\frac{1}{2} \times 64 \times 36}{840 \times 36\text{'s.}} = 2\text{lb. } 13\tfrac{3}{4}\text{oz.}$$

$37\frac{1}{2} \times 64$ gives the number of inches of weft in one inch of cloth, or, what is the same, yards of weft in one yard of cloth.

Size.—

3lb. 7oz. = 55oz.
25 per cent. on 55 =
$55 \times 25 \div 100 = 13\frac{3}{4}$oz.

The weight of the piece is then—

Twist	...	3 : 7
Size	...	$13\frac{3}{4}$
		4 : $4\frac{3}{4}$
Weft	... ...	2 : $13\frac{3}{4}$
		7 : $2\frac{1}{2}$

When the piece is measured by the long stick, about half an inch more to the yard must be reckoned—*e.g.*, 38-inch : 14/14, $37\frac{1}{2}$ yards L.S., 38's weft, to be $8\frac{1}{4}$lb. in weight; this would be perhaps $38\frac{1}{4}$ yards long S.S.

Weft.—

$$\frac{40 \times 56 \times 38\frac{1}{4}}{840 \times 38} = 2 : 10\frac{3}{4}$$

Leaving 5 : $9\frac{1}{4}$ for twist and size, say of the latter 100 per cent., then 2 : $12\frac{1}{2}$ would be twist—

$$\frac{40 \times 52 \times 41}{840} = 101\tfrac{1}{2} \text{ hanks}$$

required to be found in 2 : $12\frac{1}{2}$ of yarn; then if 2 : $12\frac{1}{2}$ = $101\frac{1}{2}$ hank : : 1lb. equals 36's twist about.

This cloth would then be composed of—

Warp	...	2 : $12\frac{1}{4}$
Size	...	2 : 13
Weft	...	2 : $10\frac{3}{4}$
		8 : 4

For quoting purposes the weight of the yarn is taken at the market price, say that of the cloth No. 1—

lb. oz.			
3 7	of 30's T at 8d.	=	2 : $3\frac{1}{2}$
2 $13\frac{3}{4}$	of 36's W at 8d.	=	1 : 11
	Weaving Price	=	$9\frac{1}{2}$

To this is added a sum sufficient to cover cost—winding, warping, sizing, power, miscellaneous expenses, waste (which sum varies considerably, and depends mainly upon the situation of the producers as regards the amount at

which he can produce this cloth). Often, for lightly-sized goods, the weaving price is doubled, making this piece cost 5s. 9½d. Should it be a dhootie, then an addition is made for coloured yarns for heading and border, and if a figured cloth extras are included for increased cost of production.

The examples given are supposititious ones, for, as has been said, the exact details of weight and quoting prices are decided purely by local or temporary position, and fixed data cannot be given as a standard for every case.

Stripe Patterns.

In case of stripes with two counts of warp yarn, for example, the number of ends of each must be obtained. If there are 38 stripes each of 15 ends, 40's twist, with a ground cloth between each of 45 ends warp, 60's T, separate calculations for each must be made.

38 × 15 = 570 stripe ends.
38 × 45 = 1710 ground ends.

Altering.

When the pick or reed is altered, the weight of the weft or warp is altered in proportion; when the length or width is altered, the weight of the piece is altered in proportion; when the counts of yarn are altered, the weight alters inversely proportionately.

Other Reeds.

Although the ¼-inch scale is mostly used for calculating warps in Lancashire, we give an example of a calculation with the Bolton reed. To get the number of ends, multiply the reed counts by the width of your warp in the reed, and by 1·6495—thus, Bolton 36's, 39 inches in the reed, would give 2238 ends. The calculation is then proceeded with in the ordinary manner. In the Scotch ell standard system, the dimensions of the cloth before-mentioned would be 36 inches wide, 36 yards long, 11^{00} reed, 11½ shots to the glass, yarns 30's/36's. To

calculate the weight of warp, add six per cent. to the 36 inches, making it 38 inches wide in the reed. If there are 1100 splits on 37 inches, then the number on 38 inches will be proportional.

$$\frac{1100 \times 38}{37} = 1130.$$

Multiply by 2, as it is always understood that there are two ends in a split, and we get 2260 ends. The calculation is then continued in the usual way.

$$\frac{2260 \times 38}{840 \times 30} = 3{\cdot}407\text{lb.}$$

Weft.—The meaning of shots on the glass refers to a counting glass used in Glasgow district, one two-hundredth part of a yard in width; $11\frac{1}{2}$ shots will then give $11\frac{1}{2} \times 200 = 2300$ picks in a yard.

$$\frac{2300 \times 37\frac{1}{2}\text{ inches wide}}{36\text{'s} \times 36\text{ inches to the yard} \times 840} = 2{\cdot}85\text{lb.}$$

If required to be left in hank, omit to divide by the counts in each case. In other materials, the length of the hank varies, and, in the case of single worsted, we should have divided in the previous calculations by 560 instead of 840, in linen by 300, or in single silk by 840.

Warping and Sizing Calculations.

In getting an order passed through a weaving shed the first point, after calculating the particulars for each piece or cut, is to get the length for warping and sizing. In the case of an order for 3750 pieces of the before-mentioned dimensions, the total length of warp is calculated thus—38 yards for one piece × 3750 = 142,500 yards, allowing nothing for waste in length, as the tension on the yarn in process will stretch it sufficiently to allow for that, and perhaps a little more. At the warping mill the length is taken in wraps of 3564 yards, subdivided into

teeth of 27 yards. In this case, four wraps or 14,256 yards would be taken to a set of back beams; therefore, this order would be run in ten separate sets.

The number of back beams for the sizing machine is proportioned to the capacity of the warping mill—say five beams, the length on each beam must be 14,256 yards, and the total number of ends on the beams equal to the ends in the piece—say 5 at 456 each = 2280.

To Calculate the Counts of Yarn after Warping.—Divide the length by the weight and 840. A beam weighs 301lb., carrying 504 ends, each 14,256 yards long—

$$\frac{14{,}256 \times 504}{301 \times 840} = 28{\cdot}41\text{'s}.$$

Having 375 pieces to make from the set of beams, which will probably weigh about 1300lb. for 30's twist, to this add 25 per cent. for size =

$$\frac{1300 \times 325}{100} = \begin{array}{r} 325 \\ 1300 \\ \hline 1625 \end{array}$$

```
                  1625
Divide by 375 )   1500 (4lb. 5oz.
                  ----
                   125
                    16
                  ----
                  2000
```

4lb. 5oz. being about the size required (*vide* page 150).

Actual Size.—To find the size actually put on the yarn, subtract the weight of the unsized yarn less waste from the sized yarn—*e.g.*,

```
         1639 Actual sized weight.
         1300
         ----
          339 = Weight of size.
1300 )  33900 ( 26·07 per cent. actual.
        2600
        ----
         7900
         7800
         ----
          100
```

Counts after Sizing.—

$$\frac{14256 \times 2280}{1639 \times 840} = 23{\cdot}61\text{'s}$$

To Calculate the Percentage of Waste.—Multiply the waste made by 100 and divide by the weight of yarn used. If eleven skips of twist, weighing 3189lb., make 33lb. of waste—

```
3189 ) 3300 ( 1·034 per cent.
       3189
       ----
       11100
        9567
        -----
        15330
```

Wages—Standard Lists.

In those towns where a uniform class of goods is made of simple weave, it is possible to formulate and adhere to a standard method of payment such as is done in Burnley, Blackburn, and other towns. In other districts, such as Bolton and Preston, the sorts are so varied and difficult to classify that at many mills a private list is adhered to with satisfaction to the employer and employed. For the benefit of some readers a typical calculation will be given, based on the 1853 Blackburn list, as in 1883 this list was adopted in Preston, Chorley, and other towns. This may be considered a list of medium position with regard to other lists—Burnley being lower for plains, Ashton list being considered a low one for fancies.

The Blackburn list is based on a 40-inch loom, weaving from 36 to 41-inch cloth, 60 reed Stockport counts, 16 picks per $\frac{1}{4}$ inch, $37\frac{1}{2}$ yards, from 30's to 60's weft, and from 28's to 45's twist, for 12·25d.

Reeds.—A 60 reed or 30 dents, being the standard, is made the starting point, and $\frac{3}{4}$ per cent. is deducted for every two ends or counts of reeds, from 60 to 48; but no deduction is made below 48 reed, and $\frac{3}{4}$ per cent. is added for every two ends or counts of reed above 60.

Weft.—All weft from 30's to 60's, both included, is considered medium, and reckoned equal, but all weft above 60's to be allowed 1 per cent. for every 10 hanks,

and all below	30's to 26's	to be allowed	2	per cent. on list.
,,	26's to 20's	,,	5	,,
,,	20's to 16's	,,	8	,,
,,	16's to 14's	,,	10	,,

Twist.—All twist from 28's to 45's, both included, is considered medium, and reckoned equal, but all twist above 45's up to 60's to be allowed 1½ per cent., and all above 60's 1 per cent. for each 10 hanks,

and all below	28's to 20's	to be allowed	1	per cent. on list.
,,	20's to 14's	,,	2	,,

Additions for Picks.—All picks above 8 and up to 18 are considered proportionate, but 8 picks and all below and all above 18, to have 1 per cent. allowed for every pick over and above the proportionate difference in the number of picks.

Width of Looms.—A 40-inch loom being the standard, is taken as the starting point, and all additions or deductions are made therefrom. (The reed space is measured from back board to forkgrate.)

26-inch loom	has	2½	per cent.	deducted from	30-inch loom.
30-inch	,,	5	,,	,,	35-inch ,,
35-inch	,,	5	,,	,,	40-inch ,,

40-inch loom (45-inch reed space) the standard—

45-inch loom	has	5	per cent.	added to	40-inch loom.
50-inch	,,	10	,,	,,	45-inch ,,
55-inch	,,	10	,,	,,	50-inch ,,
60-inch	,,	10	,,	,,	55-inch ,,

Looms of Intermediate Width.—One per cent. per inch is to be deducted from 40 down to 30-inch loom; below 30 to 26-inch loom ⅝ per cent. per inch to be deducted. Above 40-inch and up to 45-inch loom, 1 per cent. per inch to be added, and all above 45-inch 2 per cent. per inch.

Narrow Cloth in Broad Looms.—Suppose a 40-inch loom should be weaving cloth 36 to 31¼ inches in width, take off one-half the difference between 40 and 35-inch loom price; and if weaving cloth 31 to 27¼ inches wide, take off one-half the difference between 40 and 30-inch loom price; or if weaving 41¼ to 46-inch cloth in a 50-inch loom, take off one-half the difference between 50 and 45-inch loom, and so on with all other widths.

Range of Cloths.—

26-inch loom	allowed to weave cloth		up to 27 inches.
35-inch	,,	,,	from 31 to 36 inches.
40-inch	,,	,,	,, 36 to 41 ,,
45-inch	,,	,,	,, 41 to 46 ,,
50-inch	,,	,,	,, 46 to 52 ,,

Basis of Calculations.—The calculations in the Blackburn list are based upon the picks counted by the glass when the cloth is laid upon the counter. Forty yards short stick to be taken as 39 yards long stick.

To find price for a 44-inch cloth in 45-inch loom=66's reed, 44 change pinion, 528 dividend, 75 yards long, 34's/36's—

	12·25	Standard.
Add 5 per cent. loom	·61	
	12·86	
Add $2\frac{1}{4}$ per cent. reed	·28	
	13·14	
Calculate in proportion to pick 16 to 12 =	9·86	
Calculate proportion length $37\frac{1}{2}$ to 75 = Double	19·72	= List price.
Deduct 10 per cent. =	1·97	
	17·78	= Present price.

or from list under heading, 45-inch loom—

66 reed, $37\frac{1}{2}$ yards = ·822 for 1 pick.
9·86 for 12 picks.
19·72 for 75 yards.

Speeds of Shafts, Etc.

In calculating the speed of a shaft driven from another by pulleys or gearing, multiply the speed of the first shaft by the driving pulley or wheel, and divide by the driven one. A shaft makes 100 revolutions per minute and carries a 40-inch drum driving a 16-inch pulley on another shaft; the speed of the second shaft would be 250, thus :—

$$\frac{100 \times 40}{16} = 250.$$

The same rule and calculation would apply if the first shaft had carried a 40-teeth cog-wheel, and the second a 16-teeth wheel.

In taking the dimensions of a pulley for calculations the diameter is often taken; it does not matter, though, if the circumference be taken, but care must be exercised in taking the same dimension for the driven as is taken for the driver. If the diameter is taken of one, the diameter must be taken of the other.

To get Speed of Loom from Engine.—Multiply the engine speed by all the driving pulleys, and divide by the driven ones. If the engine make 46 strokes per minute, spur-wheel 105 teeth, second motion pinion 52 teeth; also on same a 52 driving a 49 on line shaft in shed. Pulley on line shaft on which is a 15-inch drum driving a loom pulley on the crank-shaft of 8 inches.

The driving and driven pulleys are always alternate; then as the first must be a driver—

$$\frac{46 \times 105 \times 52 \times 15}{52 \times 49 \times 8} = 185 \text{ nearly.}$$

The answer gives the *calculated* picks per minute. About 4 per cent. must, however, be allowed for slippage, reducing the 185 to an actual speed of about 177.

To find the Size of Pulley for any required Speed.—Find the ratio of the given speed and arrange size of pulley accordingly. Suppose a shaft running at 100 revolutions per minute has to drive a loom-shaft at a speed of 180 picks per minute the ratio of speed is as 100 to 180 or as 5 to 9; arrange the pulleys in this proportion—say 10 inches and 18 inches, the larger pulley being on the driving shaft.

To alter Speeds.—Calculate in proportion to the alteration. If a twill-shaft is driven by a 30-cog wheel, and revolves at a speed of 45 revolutions per minute for a 4-leaf twill, and it is desirable to change this to a 3-leaf twill with the twill-shaft at 60 revolutions per minute, then, as 45 is to 60, so 30 : x—

$$x = \frac{60 \times 30}{45} = 40$$

A 40 wheel must now *drive* the wheel on the twill-shaft, and the speed will be increased one-third more.

Engines.

The strength of a steam engine is indicated in horse-powers. A horse-power is taken as the capacity of performing 33,000 foot-pounds of work in one minute; lifting 3300lb. 10 feet high, or 10lb. 3300 feet high would be 33,000 foot-pounds of work.

To obtain the Indicated Horse-power—the most usual Standard.—A diagram is taken from the engine by a small apparatus, and this diagram, when measured and averaged at different points of its length, gives the mean pressure of steam in the cylinder. Multiply this by the speed of the piston, by the area of the piston, and divide by 33,000, and the I.H.P. is to hand. 39·81 average pressure per square inch, area of piston 400 square inches, length of stroke $5\frac{1}{2}$ feet, strokes per minute 40 (or 11 feet both ways)—

$$\frac{39{\cdot}81 \times 400 \times 11 \times 40}{33{,}000} = 212{\cdot}32 \text{ I.H.P.}$$

Nominal horse-power (condensing) = area of piston divided by 22; ditto high pressure = area of piston divided by 11.

$2\frac{1}{2}$ to 3 looms, with preparation, are reckoned to 1 indicated horse-power.

Coal.—A good quality of coal should evaporate 8lb. of water for each 1lb. burnt, and for a manufacturing concern (including sizing, which takes a great amount of steam) the consumption of coal should be about $3\frac{1}{4}$lb. per I.H.P. per hour. Thus 600 horse-power should use about 24 tons per week; excluding sizing, $2\frac{3}{4}$lb. would suffice.

To find the Circumference of a Circle.—Multiply the diameter by 3·1416 or (roughly) by $3\frac{1}{7}$.

To find the Area of a Circular Space.—Square the diameter and multiply by ·7854.

To find the Cubical Contents of a Rectangular Block.—Multiply the depth, length and breadth together.

City and Guilds of London Institute

FOR THE ADVANCEMENT OF

TECHNICAL EDUCATION.

TECHNOLOGICAL EXAMINATIONS.

19B.—COTTON MANUFACTURE.

Section I.—COTTON SPINNING.

I. **Syllabus.**—The Examination will include questions founded on such subjects as the following :—

1. The geographical position of the world's cotton fields, and suitable regions to which it may be introduced.

2. Cotton cultivation and the various causes of damage to the fibre during growing and picking seasons, with the dates of planting and picking in all cotton-growing countries.

3. The mode of preparing the raw material, cotton gins, ginning, packing, &c. Means and methods of adulteration.

4. Commercial handling of the raw material up to the spinning mill.

5. The nature and properties of the various kinds of raw material—Sea Island, Queensland, Fiji, Egyptian, New Orleans, Uplands Boweds, Dollerah, Hinghinghat, Surat, Brazilian, &c.

6. The selection of, and advisability, or otherwise, of mixing various cottons with a view to the full utilization of every kind.

7. The development of and the principles involved in the construction of the several machines used in cotton spinning.

8. Cleaning cotton by opening, scrutching, carding and combing machines.

9. Processes of attaining a parallel arrangement of fibres by carding, and the attenuation of the sliver through drawing, slubbing, intermediate and finishing roving frames.

10. Spinning operations upon the throstle, mule, and ring frames.

11. The doubling of single yarns for lace, hosiery, sewing thread, and kindred purposes.

12. Warping and bundling for the home trade and export, with the accompanying processes of winding and reeling.

13. Packing and commercial dealing with yarns in the process of distribution.

In the Honours Examination more difficult questions in the above subjects will be set than in the Ordinary Grade.

II. Full Technological Certificate.—The candidate, who is not otherwise qualified (see Regulations 33 and 34), will be required, for the full Certificate in the Ordinary Grade, to have passed the Science and Art Department's Examination, in the Elementary Stage at least, and for the full Certificate in the Honours Grade, in the Advanced Stage at least, in *two* of the following Science subjects:—

II. Machine Construction and Drawing.
III. Building Construction.
VI. Theoretical Mechanics.
VII. Applied Mechanics.
XV. Elementary Botany.

Certificates, showing that the candidate has passed the Second Grade Examination of the Science and Art Department in Geometrical Drawing as well as in Freehand or Model Drawing, will be accepted in lieu of one of the above Science subjects for the full Technological Certificate in either grade of the Examination.

Section II.—COTTON WEAVING.

The Examination in the Ordinary Grade will consist of a paper of questions only.

I. Syllabus.—The Examination will include questions founded on such subjects as the following:—

1. Winding Machines for warping and pirns.

2. Warping.—Mill, beam and sectional.

3. Sizing.—Ball, hank, dressing, slashing upon both cylinder and hot-air frames.

4. Beaming and Scotch Dressing.

5. Reeds and Healds (Counts Setting, &c.), Drawing in and Twisting.

6. Comparative merits of Hand and Power Looms.

7. The Power Loom—its parts, the principle governing each, with the relation and timing of each to the other.

8. Shedding Motions—as Tappets with their over and under motions. Dobbies or witches.

9. Picking motions, alternate and "pick and pick."

10. Beating up, shuttle box, and minor motions.

11. Necessary calculations for the power loom.

12. The various makes of cloth produced by Tappets and Dobbies as plain cloth, twills, satins, and small figured effects, with one warp and weft, or with the addition of extra warp for figuring, as in Dhooties.

13. Method of making designs, drafts, and tie-ups for the above.

14. Colour and colour blending as applied to the coloured branches of the industry.

15. Calculations for warp and weft and method of costing goods.

The Examination for the Honours Grade will consist of more advanced questions on the preceding subjects, especially those enumerated in Sections 7 to 11; and, in addition, questions relating to the following:—

1. Construction of the various Jacquard machines in use, and their relative suitability to various goods, and the system of mounting Jacquard looms.

2. Construction, merits and uses of the hand loom.

3. Principles of cloth structure, and the mechanism required for the production of the following typical fabrics:—Plain cloth, twills, diapers, brocades, damasks, coloured stripes and checks, warp spots, repps, weft spots produced with circles, swivels or extra shuttles, backed cloths, double cloths, 3, 4, 5, &c., ply fabrics, tapestries, velveteens, cords, Terry fabrics, plain and figured gauze, lappets, plain and figured leno.

4. Principles of designing and card cutting involved in producing the above fabrics, giving preference to the actual designing and working of such patterns as shall be practically useful as articles of commerce.

5. Analysis of samples of woven fabrics to determine pattern, draft, tie-up, and counts of material used.

6. Composition of the various yarns used in the production of mixed fabrics.

7. Latent and other defects in fabrics caused by faulty construction and unequal balancing of warp and weft.

8. Selection of warp and weft yarns suitable for the fabrics required.

9. Proportioning of fabrics so as to maintain the original structure with an increased or diminished weight.

10. Method of calculating the cost of a fabric from given data of values of material and labour, by ascertaining the fibre, counts, ends, picks and weight.

11. Actual Weaving.—Each candidate will be required, during the year preceding the Examination, to design and execute in suitable material an original pattern, of not less than 200 ends and 200 picks in a complete pattern, and to forward the same (carriage paid) to London a fortnight prior to the day of the Examination, together with a certificate signed by his employer, or by the class teacher and a member of the School Committee, stating that the work has been executed by the candidate without assistance. The specimen of weaving, showing the complete pattern, must not be less than one yard in length and at least 24 inches in width : it must be properly dyed or finished, and constructed in such a manner as to be a saleable article.

II. Full Technological Certificate.—The candidate, who is not otherwise qualified (see Regulations 33 and 34), will be required, for the full Certificate in the Ordinary Grade, to have passed the Science and Art Department's Examination, in the Elementary Stage at least, and for the full Certificate in the Honours Grade, in the Advanced Stage at least, in *two* of the following Science subjects :—

II. Machine Construction and Drawing.
III. Building Construction.
VI. Theoretical Mechanics.
VII. Applied Mechanics.
XV. Elementary Botany.

Certificates, showing that the candidate has passed the Second Grade Examination of the Science and Art Department in Geometrical Drawing as well as in Freehand or Model Drawing, will be accepted in lieu of one of the above Science subjects for the full Technological Certificate in either grade of the Examination.

GLOSSARY OF TRADE TERMS.

Am.—AMERICAN. *Sc.*—SCOTCH.]

Some words not mentioned here are explained in previous parts of the book, and will be found in the General Index.

Apex—The tip or point—*e.g.*, of a cone or wedge.

Backed Cloth—Cloth which, in addition to the faced fabric, bears bound underneath a layer either of extra weft, extra warp, or of another cloth. The term is usually applied to the first-named variety.

Bar—A term applied to a single strip of coloured weft, used as heading or cross border.

Beam—The flanged roller on which the warp yarn is wound, either at the beam. warping, sizing, or dressing machines; also applied to the full beam.

Beer—Twenty dents or splits in a reed, also 40 ends—*i.e.*, two ends to each split.

Bevel—A cog wheel, having the teeth set at an angle with the shaft on which it moves, but in the same plane, unless a skew-gear bevel.

Bitting—Drawing in additional ends at the side of healds and reeds in case of a wider warp having to be used.

Bobbin—A flanged wooden cylinder.

Borders—The stripe running along the side of a piece of cloth—formed either by different colour, counts of yarn, or weave, from the centre.

Box Motion—Arrangement for operating the shuttle boxes in check weaving.

Bracket—An attachment bolted to a framing for the support of other apparatus.

Cam or Camb—A plate revolving on a shaft, having its circumference other than circular, thus giving a reciprocating motion to any lever actuated by it.—Applied in some districts to the shedding tappets and picking plates.

Cellulose—A botanical term referring to an organic substance of which the cotton fibre principally consists, and being composed of six atoms of carbon with five of water, or $C_6 H_{10} O_5$.

Cloth—The technical name for woven cotton fabrics: although cloth is the popular name for woollen and worsted fabrics, and cotton is usually called calico, or some such name, yet in the trade the name of cloth is always given to cotton goods.

Compass Board—Another name for the cumber board.

Cop—The cylindrical coil of yarn formed at the mule, or, in the case of two-fold yarn, at the twiner.

Cord—The bands used in attaching the healds to the heald-rollers, or lambs—*i.e.*, heald cords; also a very coarse thread, used as a heading or stripe border; a name given to a cloth bearing a stripe, formed by using cord warp yarn; and also a contraction of corduroy.

Counts—A system of indicating the fineness of yarn, written by placing *'s* after the figures signifying the number of hanks per lb.—thus, "40's"; otherwise, *grist* or *numbers.*

Cover—A name given to the downy appearance of cloth or yarn.

Cross-band—Sometimes applied to yarns spun twist-way, in contradistinction to *open-band.*

Cross-border—A heading to a piece of cloth or handkerchief, either formed by coloured or other weft, or by a change in the pattern.

Cumber Board—The perforated frame for the guidance of the harness in the jacquard or some dobby shedding motions.

Cutting—The severance of the pile warp or pile weft in a fabric which requires the slitting of some filament, so as to produce a nap, formed by short threads presenting their section on the face of the cloth.

Cut—A length of warp required to weave a piece of cloth; also the piece when woven.

Deliquescent—A substance which tends to liquefy in the air—thus, chloride of magnesium tends to retain dampness and cause a fabric in which it is present to become moist.

Dent—A space between the wires of a reed, otherwise *split.*

Draft—A plan showing the order in which the ends are drawn through the healds (*see* page 94).

Elongated Twills—Twilled cloth, in which the wale extends a greater distance than usual before reaching the other side of the fabric, caused by weaving two or more picks before altering the risen ends forming the wale. These twills do not run at an angle of 45 degrees.

End—The technical name for a thread.

Entering Draft—The system of drawing the warp through the healds (*see* Draft).

Fell (of Cloth)—The edge of the fabric (in the loom) which has most recently been woven.

Filling—*Am. for* weft.

Fixing—*Am. for* tackling.

Flue—One lap of the folded cloth.

Flushing—Bringing the warp or weft to the surface of the cloth without interweaving.

Fly-reed—*Sc. for* loose reed.

Gaws—*Sc. for* goal.

Gears—*Sc. for* healds.

Goal—A gap caused in a piece by the cloth being drawn forward without the weft interweaving, especially when used to mark the end of a piece.

Grey—Yarn or cloth in an undyed or unbleached state.

Grist—Synonymous with counts (*Sc.*).

Ground—That portion of a fabric, usually of a simple weave, which serves as a base on which to display a figure.

Hank—A measurement of yarn. In cotton, 840 yards.

Harness—The arrangement of leashes in a jacquard. (*Am. for* a heald.)

Heald—The arrangement of top and bottom staves, carrying the leashes with eyes for use in stave work.—*Sc.*, heddle; *Am.*, harness.

Lag—A bar of the lattice used in dobby work.

Lathe (*South Lancashire*)—Synonymous with slay.

Lay—*Am.* and *Sc. for* slay.

Leaf—A heald or a plate of the shedding tappet—*e.g.*, three-leaf twill = three-stave twill.

Lingo—The weight below the leashes in the jacquard.

L.S.—Abbreviation of "long stick."

Mail-eye—The aperture in the harness for the reception of the thread.

Manufacturing—(*Vide* Chapter I.).

Mash—(*Vide* Index).—Otherwise smash, or trap.

Mitre Wheels—Bevel wheels which gear with and are exactly similar to each other.

Open-band Yarn—Yarn spun weft-way—that is, twisted over to the right.

P.C.—Pin cop—*i.e.*, weft size of cop.

Pick—The insertion of a thread of weft; the propulsion of the shuttle through the shed; the time occupied in the opening of the shed, the picking, and beating up.—A term used to signify the number of picks in a quarter-inch.

Pirn—A wooden tube on which is wound the weft used for headings, etc.

Ply—A thickness or layer of fabric—thus, two-ply, three-ply, refer to double or triple cloth.

Positive Motion—A motion driven by gearing as distinct from one driven by friction or some non-positive force.

Pure Size—Sizing with vegetable or animal substances, used for light percentages.

Range—A series of cloths similar in style, but varying in width or other dimensions.

Reed—(*Vide* Chapter III.).—Also the number of ends per quarter-inch.

Run—A stripe of colour in a fabric.

Scobs—*Sc. for* slattering.

Selvage—The sides of a fabric.

Sett—The fineness of reeds—reed counts. Also signifying the amount of warp on the beams which are sized at one time.

Shaft—A heald.

Shed—The opening made in the warp for the passage of the shuttle; also, a weaving mill.

Shot—*Sc. for* pick.

Slay—Otherwise *lay* or *lathe* (*vide* Index).

Smash—Synonymous with mash or trap (*vide* Index).

Split—Dent.

S.S.—Abbreviation of "short stick."

Stave—Equivalent to shaft.

Strip—A narrow bar of heading.

Stud—A short projecting pin to carry a wheel or wheels.

Tapes—Borders of cramped or coarse warp.

Tappet—(*See* Index).—*Sc. for* wiper.

Technical—Specially appertaining to an industrial art, business, or profession.

Technology—The branch of knowledge dealing with the systematic study of the industrial arts.

Terry—Uncut or loop pile.

Trap—Synonymous with mash.

Trevette—A knife used in cutting the pile wires out of the cloth.

Tuning—Tackling.

Turns (per inch)—The extent of the torsion in yarn.

T.W.—Twist-way yarn or thread, which, in being spun, has been twisted over to the left—distinct from weft-way.

Tweel—*Sc. for* twill.

Twist—Warp yarn.

Up-taking—*Sc. for* the take-up motion.

Warp—The yarn arranged length-way of the cloth—the full beam of warp yarn.

Water T.—Throstle twist.

Waves—Zigzag twill pattern.

Wax—Cotton wax is a substance coating the outside of cotton fibres, and present to the extent of about ½ per cent. It is a brownish horny vegetable wax.

Weft—The yarn arranged across the cloth.

Weft-way—Yarn twisted over to the right in spinning. Weft may be either twist-way or weft-way.

W.W.—Weft-way.

Whip-roll—*Am. for* back-rest.

Whip-thread—The crossing thread in gauze.

Woof—The weft.

Wraith, Wrathe, or Rathe—The reed comb used for guiding the yarn to the beam.

Wrap (Warper's)—*Vide* Index.

Wyper or Wiper—*Sc. for* tappets.

Yarn—The thread of twisted fibres.

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